

SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY DEPARTMENT

OF

CANADA

FOR THE CALENDAR YEAR

1902

PRINTED BY ORDER OF PARLIAMENT



OTTAWA

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EXCELLENT MAJESTY

1903

*To His Excellency the Right Honourable the Earl of Minto, Governor-General of
Canada, &c., &c., &c.*

MAY IT PLEASE YOUR EXCELLENCY :

The undersigned has the honour to lay before Your Excellency, in compliance with 3 Vic., Chap 2, Section 6, the Summary Report of the Proceedings of the Geological Survey Department for the calendar year ending December 31, 1902.

Respectfully submitted,

CLIFFORD SIFTON,
Minister of the Interior.

JANUARY, 1903.



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Geological Survey of Canada

ROBERT BELL, M.O.S.D. (HONORABLE) P.M.S. ACTING DIRECTOR
1903



Map of the DOMINION OF CANADA Showing Progress of Field Operations by the GEOLOGICAL SURVEY

1843-1903

The Illustration is the property of
Dr. ROBERT BELL, Acting Director

Scale of statute miles

Revised by the Geological Survey, 1903

No. 510

SUMMARY REPORT

ON THE OPERATIONS OF

THE GEOLOGICAL SURVEY OF CANADA

FOR THE CALENDAR YEAR 1902.

The Honourable CLIFFORD SIFTON, M.P.,
Minister of the Interior.

SIR,—In conformity with the Geological Survey Act, 53 Victoria, chapter 11, 1890, I have the honour to submit the following Summary Report of the operations of this department during the calendar year 1902. It contains a statement of the work carried on in all branches of the department, both in the office and museum and in the field. It will be seen that a large amount of original research has been accomplished and that the results of much labour and expenditure of previous years have been made available for the use of the public.

With the exception of the natural history work of the Survey, including paleontology and botany, the whole force of the department has been devoted during the past year to economic geology, with a view to promoting the development of the mineral resources of the Dominion. This applies to the chemical, mineralogical, petrological, topographical, cartological, statistical and educational work, as well as to the field operations.

Work devoted to development of mineral resources.

An erroneous impression prevails among many persons who have never had occasion to inform themselves, as to the nature of the work performed by this department. They imagine that the geologists devote themselves largely to 'theoretical and purely scientific' geology, instead of giving their attention, as they do, entirely to practical work, looking to the development of our various mineral resources.

Prevailing misunderstanding of scope of the Survey.

The Geological Survey of Canada was first provided for and organized in 1842, and field-work was begun in 1843, so that we are now in the 61st year of our existence. Our present organization and the system of work followed by the department have been evolved out of an actual experience of sixty years and in addition to this experience, the officers of the Survey have had a full knowledge of the methods

System followed.

practised by similar Surveys in other countries and have always been ready to consider any suggestion or new departure which might be of advantage in this country. Its present efficient condition is therefore due to the efforts and thoughtful consideration of a very large number of officers of proved ability and devotion, who have successfully laboured and passed away during this long period, as well as to the present staff. Every year the Survey is the object of numerous encomiums from practical scientists, both at home and abroad, who observe and appreciate its work.

Efficiency of
the Survey
recognized
abroad.

Among the notices of the operations of the Survey during the last year, the Bulletin of the Geographical Society of Paris for October, 1902, pp. 263-266, in an editorial article on the work of the Geological Survey of Canada in 1901, says: 'During the field season of 1901, not less than thirty-one geological parties organized by the Geological Survey of Canada, were sent out to cover various parts and districts of the Dominion. The operations are always conducted in a practical manner, their object being, not only the scientific study of the fields covered, but also to determine their mineral possibilities from an economic standpoint, and to fix the extent of the formations which may present some interest in this respect. When the operations are conducted over areas which have not previously been delineated, the geological party undertakes concurrently the topography and the mapping of the territory covered.'

Value of
maps and
reports.

'This work of mapping the geological and topographical features is of great practical utility, inasmuch as it brings out and makes known the great resources of Canada. Such maps and reports are a source of accurate information as to the value of the land, and the probable mineral wealth of the areas explored, affording great help thereby to both the agricultural and mining communities. At a meeting of the British Association for the Advancement of Science, recently held at Belfast, the President, Col. Sir Thomas Holdich, called special attention to the services rendered to colonization by the work of the Geological Survey of Canada. Had such an organization been at work in South Africa, the services which it might have rendered can hardly be over-estimated, and as the eminent British topographer remarks, the results which could have been obtained by such a staff in that territory would have saved many costly experiments and much tentative work. We may add that a systematic method of exploration of our colonies (those of France) conducted on the lines of the Geological Survey of Canada, would have greatly hastened their development and spared many disappointments.

To coloniza-
tion.

Clearness
of maps.

'The maps published by the Geological Survey of Canada are remarkable for their clearness and neatness of execution, and may well

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be quoted as models to be followed. For these splendid results, the Director of the Survey, Dr. Robert Bell, deserves great credit and praise. We may mention incidentally that the total annual expenses of the Survey, including administration, exploring expenses and publishing of maps amount to 579,000 francs.

Services of
the Director.

Cost.

The Summary Report of the Geological Survey of Canada for 1901 gives a resumé of the operations of the thirty-one parties sent out during the year.

In 1901 the Geological Survey published thirty-eight new maps and four profiles. There is moreover the announcement of the very early publication of a general geological map of the Dominion on a scale of about fifty miles to an inch, extending to north and east as far as Hudson strait and to the west as far as Great Bear lake.

Large issue of
new maps.

The western half of this map was issued in 1902. The topography of the eastern half is already engraved and the delineation of the geology is in progress.

TOPOGRAPHY.

Canada is indebted mainly to the Geological Survey for its present knowledge of the topography of the Dominion. Few persons have any idea of the vast amount of good topographical work which has been performed, at a comparatively small cost, by the officers of the Department during the sixty years of its existence. Although this has been only incidental to the geological work, the topographical service alone which has been rendered is worth more to the country than the whole cost of the Survey from the beginning.

Topographical
surveys made.

Following the original discoverers of the main geographical features of Canada, the officers of the Geological Survey have been the pioneers in the more accurate topographical exploration and survey of the country all the way from the southern parts, northward to the sub-Arctic regions. The accompanying map shows, on a small scale, the areas which have been more or less completely surveyed and mapped and also the routes which have been explored and surveyed in the more northern regions. These reconnaissance surveys extend through all parts of the country to a distance of about a thousand miles northward from the International boundary.

Vast extent
of country
surveyed.

Previous to the confederation of the first four provinces to form the original Dominion of Canada in 1867 and the subsequent acquisition by the Dominion of the other British possessions in North America, including British Columbia, the territories of the Hudson's Bay Company, the Labrador peninsula and all the islands lying northward of the mainland of North America, the operations of the Geological

Survey were confined to those southern portions which constitute the provinces now called Ontario and Quebec. But since confederation, in addition to the maritime provinces and British Columbia, the attention of the department has been directed to surveying topographically and geologically the vast newly acquired territories above referred to, including those portions of them which have been added to Ontario and Quebec. These great regions were entirely unsurveyed and but partially explored, only the main geographical features being roughly indicated on the sketch-maps. The subdividing of the fertile lands of Manitoba and the North-west Territories for the purpose of settlement was performed by a different department, but the running of the artificial lines required, added comparatively little topography to the map of Canada.

Dominion
Lands
surveys.

The field-men of the Geological Survey have been the first surveyors of the natural or geographical features of the immense regions referred to which constitute nearly one-half of the continent. In order to map out the rock-formations, the geologists found it necessary to make simultaneously both topographical and geological surveys. From their long experience in these operations they have been able to do this work rapidly and well. Thus an astonishing amount of accurate geographical surveying has been accomplished by a small number of devoted men with very limited means at their disposal.

CHEMICAL AND MINERALOGICAL WORK.

Dr. Hoff-
mann's work.

As shown by Dr. Hoffmann's report, herewith, this has been of the usual character during the year just closed, and has consisted largely of the examination of specimens of economic minerals which have been sent to the laboratory by miners, prospectors, explorers and land-owners in all parts of the Dominion. In each case a written report has been furnished to the inquirer. Systematic chemical examinations have also been made in regard to economic minerals of importance.

Materials
most
frequently
inquired for.

The materials about which inquiry has been most frequently made by letter or by persons calling at the department during the year have been principally the following: asbestos, barytes, bauxite, chromic iron, celestite, cement stone, clays and marls for the manufacture of cement, coal, copper ores, feldspar, fire-clay, graphite, gypsum, iron pyrites, iron ores and iron sands, infusorial earth, kaolin, molybdenite, magnesite, petroleum, platinum, peat, soapstone and zinc ores. Of these again the following were the most frequently inquired for: materials for the manufacture of hydraulic cement, molybdenite, petroleum, iron ores, kaolin and peat.

Peat.

The higher price and threatened scarcity of fuel in the greater part of Canada during the year stimulated popular interest in the peat

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resources of the country. The field officers of the department have gathered much valuable information as to the location, extent, depth and quality of peat bogs in the different provinces and the northern districts, and also as to the nature of the various attempts which have been made at different times to manufacture peat fuel.

ROOFING SLATE.

The roofing slates of the Melbourne region in the Eastern Townships do not appear to be excelled in quality by those of any other country in the world. If their merits were better known, both at home and abroad, it is probable that the demand for our slates would be much increased. The following letter from a dealer in slate addressed to Mr. Harrison Watson, Canadian representative at the Imperial Institute, London, contains interesting information on this subject:—

Excellent
quality of
Canadian
slate.

LONDON, November 14, 1902.

H. WATSON, Esq.,
Imperial Institute.

DEAR SIR,—Confirming our interview with you, we shall be glad if you will follow up the question of developing the Canadian slate trade.

The present time is very favourable, as the American trade has really stopped, on account of all the slates being required for local demand in America. In consequence of the scarcity of American and Welsh slates, buyers here have gone to France for their requirements. The French slate is not equal to the American in quality, but it is considerably cheaper. The quality of the American is between best French and Welsh and the prices are the same in proportion. The Canadian sample which we inspected at the Institute is a very good slate, and in our opinion equal if not better than the American. The sizes suitable for this market are 24-in. x 12-in., 22-in. x 12-in., 22-in. x 11-in., 20-in. x 12-in., 20-in. x 10-in., 18-in. x 12-in., 18-in. x 10-in., 18-in. x 9-in., 16-in. x 12-in., 16-in. x 10-in., 16-in. x 9-in. and 16-in. x 8-in. The slates you showed us are a little too thick, they should measure 18-in. to 19-in. per 100 slates piled up on the plate.

Demand
active.

Quarrying in America is carried on at a cost of \$1.75 to \$2 per square of 100 feet super, and the selling price is from \$2.40 to \$3 per square at quarry.

Cost of
production.

The slates have to travel, according to the different quarries, from 70 to 200 miles to shipping port. The freight to London from Philadelphia is 13 shillings and five per cent, and the London dock charges are 2s. 6d. per ton if taken by barge from ship. A square of slates weight about 575 lbs. On the above calculations the selling prices

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here are about $12\frac{1}{2}$ to 15 per cent under Welsh prices. The American slate trade with the United Kingdom in 1896 was about 46 million slates, but dropped to half the amount last year, and this year will be considerably less.

Rockland
slates.

Slates of the quality of the Rockland slate will always sell, and if prices suit we are open to make contracts for a large quantity. In our opinion the Canadian slate cleaves well and there is very little waste. The Welsh quarries produce from 100 tons rock only 10 to 20 tons clear slates; even Lord Penrhyn's quarry, which is considered the best, only produces 25 tons clear slate and 80 tons rubbish.

Proportion
of slate
to waste.

The American quarries produce from 100 tons rock about 60 tons good slates and 40 tons waste, which is mostly worked up again into electrical appliances, etc., and we believe you will find the same proportions in Canada. Slate rock is found a few feet from the top, but the deeper one goes the better the slate. An opening can be made to pay at a depth of 30 to 40 feet. There is not much machinery required to open a quarry, and the rock is so abundant in America that the waste caused by breaking the blocks to the required sizes by hand does not matter.

We can deal in slates to the following ports, to most of which there are special steamers running from Montreal: Belfast, Cork, Dublin, Glasgow, Liverpool, Bristol and London.

We shall be glad to give you any further information you may require.

Yours truly,

(Signed) A. HITT,

American Slate Company.

Mineral
collections
at exhibitions.

The collection of the economic minerals of Canada belonging to the Survey, which had been exhibited in Paris in 1900 and in Glasgow in 1901, was divided into two parts and exhibited during the past summer at the exhibitions held at Wolverhampton and Cork. Pamphlets, giving short descriptions of the mineral resources of Canada, were prepared by the Geological corps and distributed at all the above mentioned exhibitions.

Minerals
distributed
to schools.

There is an increased demand from the higher educational institutions all over the Dominion for named collections of Canadian minerals and rocks. As shown in Dr. Hoffmann's report, such collections have been supplied as far as possible, subject to certain conditions. I have no doubt these collections have been the means of creating among students and scholars a widespread interest in geology and mineralogy which would not otherwise have existed. The knowledge thus acquired

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by so large a number of young men will no doubt have an important effect in leading to the discovery and working of useful minerals in the future.

MINES SECTION.

The report of this section of the department for 1901, was published during the year and amongst other things it gives a large amount of comparative statistics of the mineral production of the country. The complete returns for 1902 are not yet received, but there are indications that there will be a considerable falling off in the output of gold and probably a slight decrease in the total of our mineral products as compared with 1901.

Mr. Ingall, who is in charge of this section, spent the greater part of the summer in making a detailed geological survey of an area measuring about 20 miles square behind the Bruce Mines. He was assisted in this work by Mr. T. Denis, formerly of the same section, and three students. Mr. Ingall's work.

PALEONTOLOGY.

Dr. Whiteaves has completed Part V., vol. I, of his Mesozoic Fossils and it is now in type (106 pp.) The figures for ten of the twelve plates which are to accompany it have been drawn by Mr. Lawrence M. Lambe, and these will be lithographed in Canada, while the remaining two plates have been already lithographed and printed in England. A quarto memoir, forming Part 2, volume III of the 'Contributions to Canadian Paleontology' was published during the summer. It is 'on the Vertebrata of the Mid-Cretaceous of the Northwest Territory' by Professor Henry Fairfield Osborn and Mr. Lawrence M. Lambe and contains 81 pages of text with numerous figures and 21 fine photogravure plates. A description, with figures, of a new species of Osmundites from the Queen Charlotte Islands, prepared for the Survey by Professor Penhallow, of McGill University and illustrated by several figures, is published in the Proceedings of the Royal Society of Canada for the present year. Part 2, volume II, of Professor Samuel H. Scudder's 'Canadian Fossil Insects' was published by the department during the previous year. Dr. Ami's paleontological work has consisted largely of the determination of collections of fossils for the purpose of identifying geological horizons. Dr. Whiteaves' work.
Mr. Lambe's reports.
Dr. Ami's determination of fossils.

BOTANY AND ZOOLOGY.

During the summer, Professor John Macoun visited the Yukon valley and stayed for some weeks at Dawson for the purpose of studying the climate, the indigenous flora and the agricultural possibilities. Professor Macoun's report on the Klondike.

- of the Klondike district. The results, as set forth in his report, proved to be of much interest and economic importance. Part VII, being the concluding volume of Professor Macoun's catalogue of Canadian plants, was published during the year. It is on the Lichens and Hepaticae, and contains 318 pages. Part II of the catalogue of Canadian birds by the same author is well advanced and will be issued in 1903. Part III will complete the series. Mr. James M. Macoun, assistant botanist and naturalist, did a successful season's work with the International Boundary Commission in southern British Columbia, and among other results brought home large and interesting collections of plants, birds and mammals. Mr. Lawrence W. Watson, who in 1901, collected plants and studied the flora of Prince Edward Island for the Survey, has completed his list of the plants of that province and it is intended to publish it as soon as possible.
- On lichens, birds, etc.
- Mr. J. M. Macoun.
- Mr. Watson's flora of P.E.I.

FLORA OF HUDSON BAY.

- A memoir on the flora of Hudson bay, based on the plants collected around that sea at various times and places by the officers of the Survey, has been prepared by Professor John Macoun, Mr. J. M. Macoun and Dr. Theodore Holm of Washington. These collections were found to contain ten new species of flowering plants, which have been described jointly by the three botanists just named. Dr. Holm has made drawings of each species to illustrate the descriptions and these will be reproduced in the form of ten plates to accompany the memoir. The work will be issued as one of the special publications of the Survey.
- Flora of Hudson bay.
- Theodore Holm's drawings.

MAPS.

- The preparation and engraving of maps, resulting from the field-work of the officers of the Survey, has been pushed forward with great energy under the direction of Mr. C. O. Senécal, the geographer and chief draftsman of the department. This officer's report contains full particulars of the work accomplished and a statement of the maps published during the year.
- Work of Mr. C. O. Senécal.

OTHER PUBLICATIONS.

- The following reports and special works have also been published by the Survey in 1902:—
- List of publications in 1902.

Summary Report of the Geological Survey for the calendar year 1901, pp. 269, with 3 sections, 4 plates and 10 maps.

Part A. vol. XIV., with 10 maps, plates, and sections, by the geological corps.

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Report on the surface geology shown on the Fredericton and Andover quarter-sheet maps, New Brunswick, Part M, vol. XII., pp. 41, by Dr. Robert Chalmers.

Notes on certain Archæan Rocks of the Ottawa Valley, Part O, vol. XII., pp. 84, by Prof. Osann.

Report on an Exploration of the east coast of Hudson Bay, Part D, vol. XIII., pp. 84, with maps, by Mr. A. P. Low.

Report on Explorations in the north-eastern portion of the District of Saskatchewan, &c. Part F, vol. XIII., pp. 48, by J. B. Tyrrell.

Report on Geological Explorations in Athabasca, Saskatchewan and Keewatin Districts, &c. Part FF, vol. XIII., pp. 44, by Mr. D. B. Dowling. The Grass River map-sheet accompanies Reports F and FF.

Report on the Nottaway River basin. Part K, vol. XIII., pp. 11, with a geological map, by Dr. Robert Bell.

Report on the Geology and Petrography of Shefford Mountain, Quebec, by Principal J. A. Dresser. Part L, vol. XIII., pp. 35.

Report upon the Carboniferous System of New Brunswick, &c. Part M, vol. XIII., pp. 38, by Professor L. W. Bailey.

Report upon the Carboniferous System of New Brunswick, &c. Part MM, vol. XIII., pp. 38, by H. S. Poole, Esq.

Section of Mines Annual Report for 1900. Part S, vol. XIII., pp. 160, by Mr. E. D. Ingall and Mr. McLeish.

Annual Report, vol. XII. (new series), 1899, English edition, pp. 972, with 8 maps.

Annual Report, vol. XI. (new series), French edition, pp. 934.

Catalogue of Canadian Plants, Part VII., Lichens and Hepaticæ, pp. 318, by Prof. John Macoun.

Contributions to Canadian Paleontology, vol. III. (quarto). Part II., "On Vertebrata of the Mid-Cretaceous of the North-west Territory," by Professor Henry Fairfield Osborn and Mr. Lawrence M. Lambe, 81 pages, illustrated with numerous text-figures and twenty-one photogravure plates, viz.:—

1. Distinctive characters of the Mid-Cretaceous Fauna, by Prof. Henry Fairfield Osborn ;
2. New genera and species from the Belly River series (Mid-Cretaceous), by Lawrence M. Lambe ;

FIELD WORK.

As in the previous year, as many field parties as our funds would permit of were sent out, including some under the control of geologists not connected with the Survey, but employed for the season only. Twenty-two parties or geologists, working independently of each other, were engaged in field operations. In some cases where the assistants were able to do good topographical or geological work, the party was divided after reaching its ground and the two sections worked separately for the greater part of the season, so that the total number of field officers operating independently may be said to have been twenty-seven. Most of these officers remained out during the whole season, but a few of them for a shorter period.

Twenty-seven
field officers
at work.

Following the plan adopted last year, the report of each field and staff officer is given separately and as the field operations and other work of the department are thus fully explained, it is only necessary for me here to give a brief outline of the former, enumerating the regions covered in their order from north-west to south-east, as in last year's Summary Report.

R. G. McConnell's survey
of Macmillan
river.

The most northerly expedition was that of Mr. R. G. McConnell, who, with Mr. Joseph Keele as assistant, made an instrumental topographical survey and a geological reconnaissance of the Macmillan river, a stream nearly as large as the Ottawa, which falls into the Pelly from the east, a short distance above the point where the latter joins the Lewes to form the Yukon. On reaching the forks of the Macmillan the instrumental survey was discontinued and Mr. McConnell explored the northern branch, while Mr. Keele traced the southern. In addition to the work done along the main river and its branches, the hills and mountains on either side were ascended at frequent intervals for the purpose of examining the rocks. It was found that from the mouth of the river to the highest points reached, the main stream and both its branches flowed over crystalline rocks, mostly altered sediments. Samples were collected from a number of quartz veins and it was hoped that some of these would be found to contain gold, but on assay in the laboratory of the Survey, none was found. The results of the above work are, therefore, valuable principally on account of the new topography and geology acquired, as well as the general information in regard to the nature of the country through which the Macmillan river flows.

Barren quartz
veins.

Vancouver
island.

Up to the past season, no examination had been made by the Geological Survey of the outer or south-western coast of Vancouver island, except for a few miles at the north-western extremity. As it had become important to obtain information in regard to the rocks and pos-

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sible economic minerals of this coast, it was decided to send a party to work there. For this service, Mr. Arthur Webster, a former member of the staff and Professor Ernest Haycock of Acadia College, Wolfville, Nova Scotia, were selected. The coast, being bold and exposed to the sweep of the Pacific ocean, was found difficult to examine by means of a small boat. Still, these gentlemen succeeded in exploring it from the Straits of Fuca to within a short distance of the north-western extremity of the island. From their reports it will be seen that along the whole coast, granites and basic eruptives are largely developed, while unaltered sedimentary rocks are frequently found resting upon them. Ores of copper occur in several places and in some instances they appear to exist in promising quantities.

Survey by
Webster and
Haycock.

Ores of copper.

Dr. R. A. Daly continued the work begun the previous year along the International boundary between British Columbia and the State of Washington and to a distance of ten miles to the northward of it. The rocks examined in the field consist mostly of altered sediments and eruptives. Dr. Daly is now making a petrographic study of these rocks and of the structural and physiographic geology of the ground he worked over.

Dr. Daly's
work.

Mr. James M. Macoun was employed as naturalist near the International boundary in the same region as Dr. Daly. Besides studying the fauna and flora on the ground, he made valuable collections of mammals, birds and plants.

J. M. Macoun,
Naturalist to
Boundary
Commission.

Mr. R. W. Brock and Mr. W. H. Boyd investigated a mining area of about fifteen miles square around the town of Greenwood, in the boundary district in British Columbia. The latter attended to the topographical work, while the former traced out the limits of the various rock-masses and studied their petrography. A map of this area is being prepared to show the geology and the hill-features by means of contour lines.

Greenwood
mining area.

In the region between the Slave and Peace rivers of the great Mackenzie basin, Mr. C. Camsell worked in the district to the westward of Fort Smith, which is situated about midway from Athabasca lake to Great Slave lake. He made a track-survey of a canoe-route between the Slave and Peace rivers, but his principal work consisted of investigations as to the occurrence of salt and gypsum in the Devonian rocks of this country. He went by the Athabasca river and returned by way of the Peace.

Explorations
in the
Mackenzie
basin.

Salt and
gypsum.

Among the Rocky mountains and along their eastern flanks, coal of good quality occurs in great quantities in Cretaceous rocks for a long distance northward from the International boundary. In the Crows-nest Pass coal-field, which is being developed on the line of the Canadian

Crows-nest
coal field.

Section. Pacific railway, in a total section of 4,736 feet there are 22 seams with an aggregate thickness of 216 feet of coal, of which over 100 feet are workable under present conditions. Coal basins run with some interruptions for hundreds of miles northward from the Crows-nest Pass. In the foot-hills on the east side of the Rocky mountains, the coal seams are repeated and they are traversed by the southern branch of the Canadian Pacific railway in the district of Alberta. During the past season the geology of a considerable area of the coal belt in the vicinity of Blairmore was investigated by Mr. W. W. Leach. A map of this area by Mr. Leach accompanies his report in the present volume, in which much valuable information is given as to these coal-bearing rocks. Coal crops out in many places and is probably widely distributed in our prairie region east of the Rocky mountains. This abundance of good fuel will add greatly to the value of these agricultural lands.

W. W. Leach's
report and
map.

Mr. Dowling's
work in
Manitoba and
Assiniboia. Lignite of Tertiary age is found in seams of moderate thickness in the Turtle mountain region of southern Manitoba and in the Souris river country, lying to the westward, in Assiniboia. These lignites were investigated last season by Mr. D. B. Dowling and found to be of more economic value than had been supposed. Mr. Dowling also made some investigations in connection with the occurrence of gypsum between Lakes Winnipeg and Manitoba.

Gypsum.

Albany and
Severn rivers.

Between the head-waters of the Albany and the Severn rivers, a large region remained unexplored both geographically and geologically. During the past season part of this was examined by Dr. Alfred W. G. Wilson, assisted by Mr. Frank Johnson. It proved to be a level country with here and there a low ridge or knob of Laurentian gneiss. Two narrow belts of Huronian schists were found.

Explorations
on James bay
by W. J.
Wilson and
O. O'Sullivan.

On the west side of James bay, three good-sized rivers remained to be surveyed. One of these, the Kapiskau, falls into the bay between the Attawapiskat and the Albany, while the two others lie between the Albany and the Moose. These were surveyed, both topographically and geologically by Mr. W. J. Wilson and Mr. Owen O'Sullivan. On all these streams they met with only the same nearly horizontal Devonian rocks which had been found by myself on all the other principal rivers to the west and south of James bay, and these rocks were also overlaid everywhere by a thick mantle of stiff clayey till, like that along the streams which had been previously surveyed. The economic minerals of this region consist of gypsum and clay-ironstone in the Devonian strata, while workable beds of lignite, apparently of considerable extent, occur in the drift along the Moose river and some of its northern branches.

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In 1901 it was decided to complete two of our regular topographical and geological map-sheets, each covering 72 miles from east to west by 48 miles from north to south, in order to show the whole Lake Nipigon region, the lake itself occupying the central portion of the united sheet. The field-work necessary to complete the west half of the southern sheet was done by Dr. Alfred W. G. Wilson in 1901, and that required in the east half of this sheet by Dr. W. A. Parks of Toronto University, the same season. In 1902 the latter worked out the requisite details in the east half of the northern sheet, while Mr. William McInnes finished the west half of the same sheet. The resulting topographical and geological map of the whole country around Lake Nipigon, measuring 72 miles from east to west and 96 miles from north to south, is well advanced. It is a valuable addition to the geography of Northern Ontario and the distribution of the different rock-formations is such that it shows a considerable diversity of geological colouring.

Lake Nipigon maps.

Work done by Drs. Wilson and Parks.

By William McInnes.

Discoveries of copper have been made in the last few years in the country behind the Bruce Mines on the north shore of Lake Huron, and it was considered desirable to make a more detailed geological survey of this district. Accordingly, Mr. E. D. Ingall, Chief of the Mines section of the Survey, was instructed to undertake this work. He was assisted by Mr. T. Denis, also of the geological corps, and a survey was made of a tract embracing about twenty miles square in the country immediately north of the Bruce Mines, most of which is now settled. Another season will be required to trace out accurately the remaining geological lines of this area. We shall then have a map showing better than does the existing one, the boundaries of the rock-formations in this interesting part of the original Huronian area.

Bruce copper mines.

Surveys by E. D. Ingall and T. Denis.

Dr. A. E. Barlow was instructed to continue his researches among the nickel-bearing rocks of the Sudbury district. These have been found to belong to three belts—a northern, a middle and a southern. The rocks of this district have proved to be of considerable lithological interest. The various granites and greenstones have been differentiated and the relations of the nickel deposits to them determined to a considerable extent.

Nickel ores of Sudbury.

Professor F. D. Adams and Dr. A. E. Barlow had been engaged for several seasons in working out in detail the geographical distribution of the subdivisions of the Laurentian rocks within the limits of one of our regular map-sheets, covering an area of 72 miles from east to west, by 48 miles from north to south. This map has been called the 'Haliburton sheet.' Dr. Adams visited this region during the past summer in order to ascertain some details required to finish the mapping of certain geological lines. The engraving of this map in black has been

Work by Professor Adams and Dr. Barlow for the Haliburton sheet.

completed for more than a year and now that the geology has been laid down upon it, only the latter remains to be engraved and printed. In the region covered by the Haliburton map, there is an unusual variety of Laurentian rocks, and these have now been mapped with so much care that this will be the most complete representation of an Archaean area yet produced in America. A map of a portion of the same area, with some additions, has been completed on a larger scale and will be published about the same time.

Surveys for
Kingston map
by Dr. R. W.
Ells and Mr.
Hugh Ells.

In the country around Kingston, Ontario, Dr. R. W. Ells and Mr. Hugh Ells have nearly finished the field-work necessary for completing the 'Kingston sheet,' the area covered measuring 72 by 48 miles. The irregular contact of the Ordovician with the Archaean rocks runs through the sheet and requires much detailed field-work in order to locate all its sinuosities.

Dr. Chalmers'
investigations
in surface
geology.

Dr. Robert Chalmers, whose time is devoted to surface geology, wells and artesian borings, worked again during the past season in the inter-lake peninsula of Ontario. In addition to investigations connected with underground waters, petroleum, gas and salt, he examined the clay deposits from both a geological and economical point of view. He also traced carefully and mapped out some of the ancient beaches, so well developed in that region, from Lake Huron eastward to the vicinity of the outlet of Lake Ontario. A map showing a portion of the latter work accompanies his report.

Copper mines
of the Eastern
Townships.

In the copper region of the Eastern Townships (which lie between the St. Lawrence river, on the one hand, and the states of Maine and New Hampshire on the other) it was believed that by studying petrologically the rocks associated with the copper ores, we might be able, by combining the results with the stratigraphy, to recognize and limit more accurately the copper-bearing belts. The field-work and the microscopic study connected with this investigation were undertaken by Principal Dresser of St. Francis College, Richmond. He has found that the copper ores are confined mainly to three principal belts, consisting mostly of basic eruptives. The results of his work promise to lead the way to discoveries of economic value.

Discoveries
by Principal
Dresser.

Dr. Ells'
investigation
of the
petroleum of
Gaspé.

Dr. Ells was instructed to investigate the petroleum problem in the peninsula of Gaspé, which forms the extremity of the land on the south side of the lower St. Lawrence. For more than half a century the existence of petroleum in this region has been known to the Geological Survey. For a number of years back, the district has been exploited by companies formed in Europe and many deep wells have been bored. Until last year, it was difficult to secure much reliable information as to the results that were being obtained. But all the

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obstacles having been removed, Dr. Ells was able to collect, during the past season, full and accurate information as to the outcome of the operations of all the different companies. This is a matter of great importance, and, owing to the facilities afforded Dr. Ells for his investigations in all parts of the reported oil region, he has been enabled to prepare an interesting report on the whole subject.

The same gentleman also spent a part of the season in investigating questions as to the possibility of finding coal within workable depths in Prince Edward Island. As a result, boring operations will probably be commenced next year by the local government in the hope of finding coal seams within reach under the Upper or Permo-Carboniferous rocks of the island.

The northern interior of New Brunswick, or the region around the head-waters of the Tobique and Nepisiguit rivers, was further explored by Professor L. W. Bailey of the University of New Brunswick, who has worked for the Survey for many years. Dr. Bailey was assisted by Mr. Robert Johnston of the regular staff. Their exploration shows that further investigations will be required before the geology of that region can be satisfactorily laid down upon a map.

Mr. H. S. Poole, who had been engaged during the season of 1901, in going over the Carboniferous rocks of New Brunswick in the hope that he might discover a possibility of the occurrence of workable coal seams, was requested to examine the region lying around Chignecto bay, so as to confirm or correct our previous mapping of the rock-formations in that neighbourhood and to establish more clearly the relations of the Carboniferous rocks of New Brunswick and Nova Scotia.

Mr. E. R. Faribault has been engaged for a number of years in making topographical and geological surveys of the gold districts of Nova Scotia and mapping each one separately. He spent a part of the year in preparing several of his plans of these districts for publication and the remainder of his time in the field. He was again assisted by Mr. A. Cameron and Mr. J. M. Cruickshank, who have been engaged on this kind of work with Mr. Faribault for a number of years.

Mr. Hugh Fletcher was again engaged in Nova Scotia, principally on work connected with the coal-bearing rocks. On account of his familiarity, from past experience, with the geology of the various coal fields of Nova Scotia, which are now undergoing active exploration or development, his services were requested to visit different places where new work was in progress, in order to give advice as to the best course to pursue by the operators. The latter part of the season was devoted to a continuation of his investigations in the Springhill coal-field. He

Prospect of
finding coal in
Prince
Edward
Island.

Surveys
in New
Brunswick by
Professor
Bailey and
Mr. Johnston.

By Mr. H. S.
Poole in New
Brunswick
and Nova
Scotia.

Gold districts
of Nova
Scotia mapped
by Mr.
Faribault.

Coal mines of
Nova Scotia.

Springhill.

was assisted by Mr. McLeod and Mr. Allan McKinnon. The various kinds of work in which he and his assistants were occupied are described in his report in this volume.

Inspections by Dr. Bell. My own field-work consisted of visits of inspection to the Michipicoten district, Lake Superior, the region behind Bruce Mines, Lake Huron, where Mr. Ingall and Mr. Denis were at work, the county of Frontenac, the copper discoveries near Matane on the south side of the St. Lawrence about 220 miles below Quebec, and to some of the gold and coal districts of Nova Scotia, including Cape Breton.

Exploration of Albany district by Jabez Williams. I should here mention that Mr. Jabez Williams, an officer of the Hudson's Bay Company, now resident at Osnaburgh House, who has a good knowledge of prospecting, has sent me a report on an exploration which he made the previous year of a tract of country lying north of the section of the Albany river between Eabamet and Martin falls, of which we had previously but little geological knowledge. Mr. Williams' report was accompanied by a collection of specimens of the rocks which he met with. The report and specimens will aid us in mapping the geology of the Albany district, and the thanks of the department are due to Mr. Williams for this valuable contribution.

Contributions by A. P. Low. We are also indebted to Mr. A. P. Low, (for many years a regular member of the staff of the Survey) for several original maps and a detailed report on the geology of the Hopewell group of islands and a number of the islands of the Nastapoka group, on the east side of Hudson bay. Mr. Low did the field-work in 1901 for the Dominion Development Company of Philadelphia, which kindly consented to allow him to present these valuable results to the department for publication. The maps have been used in the compilation of the sheet that is being engraved to accompany Mr. Low's report for 1900, which is to form part of volume XIII., (N.S.,) of our regular annual reports.

Supplement to J. B. Tyrrell's work in the Yukon district. In 1896 Mr. J. B. Tyrrell, before severing his connection with the Survey, made an examination of the Dalton trail from the head of the Lynn canal to the Lewes river in the Yukon district, but he deferred sending in his report on this work until he could obtain petrographical descriptions of the series of rock-specimens which he had collected while engaged upon it. Thin slices of these specimens have been made in Germany and with the aid of these, Dr. Barlow is drawing up a description of this series of rocks, to be forwarded to Mr. Tyrrell, who is now residing at Dawson, Yukon district.

Report on E. Coste's map of Madoc and Marmora. In 1883, Mr. Eugene Coste made a geological examination of the townships of Madoc and Marmora for the Survey, and the map to illustrate his report was engraved and printed in colours the following year. It is now expected that Mr. Coste will furnish a report on the above work to be issued along with this map.

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GEOLOGICAL NOMENCLATURE AND THE COLOURING OF GEOLOGICAL MAPS.

The want of a uniform system of geological nomenclature and map-colouring, applicable to the whole of North America, has long been felt. This has been the case more especially in late years when it has become necessary to colour geological maps of large areas, so that they may be in harmony on both sides of the International boundary. There is likewise a lack of uniformity as to the terms which are employed to distinguish the various geological periods. The absence of a general agreement in these matters was also felt many years ago by the geologists of all the countries of Europe and it was from this circumstance that the International Geological Congress arose in 1876.

Uniform system of Geological nomenclature necessary.

In 1881, the late Dr. Selwyn proposed a scheme of geological nomenclature and of colouring of geological maps, in order to secure uniformity in the reports and maps of the Canadian Survey, but this was not adopted elsewhere. (See Report of Progress of the Geological Survey of Canada for 1880-82, pp. 47 to 51).

In 1901, the geological and biological section of our Royal Society (Section IV.) seeing the necessity of moving in this important matter, passed a resolution, requesting the writer to convene a committee of geologists of his own choosing, to consider all matters connected with the nomenclature of geological divisions in Canada. The following report explains what was done in the matter.

REPORT OF THE COMMITTEE OF THE ROYAL SOCIETY ON THE NOMENCLATURE OF GEOLOGICAL FORMATIONS IN CANADA.

OTTAWA, 22nd May, 1902.

The Secretary,
Section IV, Royal Society of Canada,
Toronto.

SIR,—At the last meeting of the Royal Society, I was requested by Section IV to select a committee of geologists, of which I was to act as convener, to take into consideration The Nomenclature of Geological Formations in Canada.

Action taken at Royal Society meeting.

In the beginning of May, a committee for this purpose was named and a meeting called for the 10th, of the month. The following geologists were invited and all accepted :—Dr. J. F. Whiteaves, Dr. R. W. Ells, Mr. Hugh Fletcher, Mr. R. G. McConnell, Dr. Robert Chalmers, all of the Geological Survey, Professor W. G. Miller, Provincial Geologist, Toronto, Professor F. D. Adams, McGill University, Montreal,

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Mr. B. E. Walker, Toronto, Dr. George F. Matthew, St. John, N.B.,
Professor H. S. Poole, Dalhousie University, Halifax.

The meeting called for the 10th of May, was held in my office in Ottawa and was attended by all the members, except the three last mentioned. Mr. Walker was about to sail for Europe and Dr. Matthew and Professor Poole were unable to come so far.

Opinion of
committee.

After considerable discussion, it was the general opinion of the committee that there is need for a uniform and better understanding as to the significance, not only of the proper names in use (for the divisions of the geological scale), but as to the relative comprehensiveness and classification of geological divisions themselves.

The unnecessary multiplication of so-called formational names was deprecated and it was felt that it would be advantageous if some method could be adopted by geologists, which would allow of a general consideration or discussion of proposed new names for divisions of rocks before they were recommended for adoption.

Dr. J. F. Whiteaves, Mr. H. Fletcher, Mr. McConnell and Dr. Adams were appointed a sub-committee to consider the names of the various divisions of the whole sedimentary series in Canada, from the Archaean up to the Pleistocene.

Co-operation
of United
States and
continental
geologists
desirable.

It was considered desirable that the present committee should be authorized by section IV to enter into correspondence with the Geological Survey of the United States or any other body of geologists on the continent, with a view to securing, as far as possible, greater harmony and uniformity in the nomenclature of geological divisions, subdivisions and masses of rocks of all ages throughout North America.

The committees then adjourned with the intention of meeting, if possible, during the session of the Royal Society in Toronto.

Respectfully submitted,

(Signed) ROBERT BELL,
Convener.

The foregoing report was read at the Toronto meeting, at which it was adopted and the committee continued, with power to add to its numbers.

Conference
with American
geologists in
Washington.

Later in the year, after some correspondence on this subject with Professor Charles D. Walcott, Director of the Geological Survey of the United States, and Professor C. R. Van Hise of the same Survey,

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who has taken a great interest in the matter, it was arranged that the writer should meet and confer with these gentlemen in Washington. Professor Walcott named Dr. C. W. Hayes and Professor Van Hise, to meet Dr. F. D. Adams and myself as a joint committee to discuss the whole matter and make arrangements for carrying out the objects in view. The results are given in the following document :—

Minutes of meeting of joint committee on nomenclature, consisting of Drs. Robert Bell and Frank D. Adams, representing the Canadian Geological Survey, and C. W. Hayes and C. R. Van Hise, representing the U. S. Geological Survey, held at Washington, D.C., January 2, 1903.

C. W. Hayes in the chair.

Present also Messrs. Bell, Adams and Van Hise.

1. It was agreed that the committee, as constituted by mutual consent between the Directors of the two Surveys concerned, should form a permanent committee and should appoint sub-committees for the consideration of questions of nomenclature in various regions along the United States-Canadian Boundary. It was agreed that the nomenclature of these regions should be taken up as rapidly as the necessary information for a satisfactory adjustment should become available, and that during the coming year the questions of nomenclature in the Adirondack and Lake Superior regions should be considered.

Sub-committee selected.

2. It was agreed to submit questions of nomenclature in the Adirondack region to a sub-committee, consisting of Messrs. Van Hise and Adams, who were instructed to confer and report their recommendations to the full committee.

3. It was agreed that questions of nomenclature in the Lake Superior region should be considered by a joint sub-committee, consisting of Prof. C. R. Van Hise, Mr. C. K. Leith, and, by invitation, Dr. A. C. Lane, State Geologist of Michigan, on the part of the United States, and Acting Director Robert Bell, Prof. Frank D. Adams, and, by invitation, Mr. W. G. Miller, Geologist for the Province of Ontario, on the part of Canada.

4. It was agreed that this sub-committee should make arrangements by correspondence between Messrs. Van Hise and Bell, Chairmen of the sub-committees, for a joint field conference during the coming field season.

5. It was agreed that the permanent joint committee should hold a meeting in connection with the next winter meeting of the Geological Society of America, and, if necessary, other meetings at the call of the Chairman.

(Signed) C. W. HAYES,
Chairman.

Shortly after the above meeting had been held, it was found that some of the American geologists who had been designated would not be able to proceed to carry out the necessary joint field-work this season, and it was, therefore, agreed to postpone active operations till next year. Meantime, it is expected that some progress towards the ends desired, will be made by a more careful study of the reports which have been written as to various controverted points and by conferences in regard to them. It is confidently expected that the active combined field-work of the committee will be commenced in the spring of 1904.

OFFICERS REPORTS.

THE MACMILLAN RIVER, YUKON DISTRICT.

Mr. R. G. McConnell.

Work by R.
G. McConnell
and Joseph
Keele.

The work during the season of 1902, consisted in making an examination of the Macmillan river, one of the principal feeders of the Pelly. I left Ottawa on the 7th of June, accompanied by Mr. Joseph Keele, and reached Whitehorse, where we outfitted, on the 17th of June, and Fort Selkirk at the mouth of the Pelly, on the 22nd. Two days afterwards we proceeded up the Pelly river, carrying our summer supplies in two Peterborough canoes which we had brought with us from Ontario.

The party consisted of Mr. Keele, who acted as topographer and assistant geologist, the writer, and two canoe-men from Sault Ste. Marie. We were delayed on the Pelly by the flooded condition of the river, the highest rise of the season occurring on June 29, and did not reach the mouth of the Macmillan until July 5.

Survey of
Macmillan
river.

The early part of the season was occupied in making a traverse by micrometer up the Macmillan to the forks, a distance of about 150 miles. The micrometer traverse was afterwards continued by Mr. Keele up the South fork for a further distance of fifty miles. The North fork proved to be an exceedingly rapid stream, very difficult to ascend, and as time was limited and it was important to explore both branches, Mr. Keele was directed to survey as much of the South fork and its tributaries as possible, while the writer continued on up the North fork. This was ascended to a point a few miles above Cache creek, and then the latter stream was followed to its head. We had been informed that it headed with Peel river, but this proved to be incorrect. The valley occupied by Cache creek connects the Macmillan with the South fork of the Stewart, and from the top of a mountain at its head, which was ascended, the valley of the Stewart could be traced at least thirty miles in a north-easterly direction. The head of

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Cache creek, the farthest point gained, was reached on August 12, and on the 13th we commenced the return journey. A number of mountains had been selected for climbing on the way up, and stoppages of from one to three days were made at those points on the way down. A micrometer traverse was also made of the Pelly from its junction with the Macmillan to Fort Selkirk at its mouth.

General Description of Macmillan River.

The Macmillan river has a total length of about 285 miles. It divides at 150 miles above its mouth into two nearly equal branches, known as the North and South forks. The North fork carries the most water, and has a length of about 135 miles. The South fork is probably of nearly equal length.

Length of
North and
South forks.

The main river, in its lower reaches, is a winding stream varying in width from 300 to 500 feet. The current is sluggish, seldom exceeding, in the first fifty miles, a rate of three miles an hour. The valley has a width of from one to five miles or more and is covered with a heavy deposit of clays, silts, sands, gravels and boulder clay. The river has cut a great trench in these deposits usually about 200 feet in depth, and from one mile to two miles in width, and now winds from side to side of this depression, occasionally cutting into and destroying portions of the bordering banks. In the lower portion of the river the cut banks consist largely of a bluish plastic clay, and at several points great masses of this material have slid forward and in some instances formed barriers extending nearly across the river. The drift plain bordering the river banks is bounded on both sides by ranges and groups of hills and mountains, rising from 2,000 feet to nearly 5,000 feet above the level of the valley.

Cut banks of
plastic clay.

The easy current characteristic of the lower portion of the Macmillan is interrupted about fifty miles above its mouth, by a stretch of comparatively rapid water five or six miles in length, above which the current is again generally slack for a further distance of fifty miles, although a few riffles occur. In the upper fifty miles, the current becomes much swifter, flowing at a rate of from three to five miles an hour. The swiftest stretches occur at places where the stream has recently broken through the necks of ox-bow bends, and so shortened its course. The greater portion of the river is easily navigable, except at low water, by small steamers.

Navigable
by small
steamers.

The principal difficulty occurs at Porphyry bluff. The river at this point runs swiftly around a number of sharp bends and the channel is filled with snags. The latter could easily be removed if necessary. The grade of the Macmillan was estimated at from one to two feet per

mile in the lower portion of the river and from two to four feet in the upper portion. The average grade throughout, probably amounts to about three feet to the mile and the total fall from The Forks to the Pelly is estimated at 450 feet.

Principal
streams enter-
ing Macmillan
river.

The principal feeders of the Macmillan below The Forks are Kalzas river, Moose river and Russell creek. The streams are all northern tributaries, no important feeders entering the river from the south. Kalzas river, which joins the Macmillan twenty-seven miles above its mouth, is a large rapid stream about sixty feet in width. It forks a short distance above its mouth, the principal branch occupying a wide terraced valley, which extends in a north-easterly direction for a distance of about forty miles. The north-westerly branch empties Kalzas lake, a sheet of water about six miles in length, lying behind the Macmillan mountains. This branch follows part of an old valley, which has been traced from the Pelly, in a north-westerly direction to the Klondike and beyond. This valley is occupied in different parts of its course by a portion of the Pelly, a branch of Kalzas river, Crooked creek, a portion of the Stewart river, Clear creek, Flat creek, and the lower part of the North fork of the Klondike river. This ancient drainage channel is an important topographical feature of the country, and may prove to be of economic value, as gold may be concentrated in portions of its course. It runs in a north-westerly direction, crossing the present main drainage channels diagonally, and has a width of from two to ten miles or more. In the glaciated area, it is bordered by wide terraces built up of silts, sands, gravels and boulder clay, and in the unglaciated area, north of the Stewart, it is filled to a depth of at least 600 feet with sand and gravel.

Ancien drain-
age channel.

MOOSE RIVER.

Moose river, which enters the Macmillan about midway to the Forks, also occupies an old valley which extends in a north-easterly direction to the South fork of the Stewart, but has not been traced beyond. Moose river is a winding stream about 50 feet in width and a length measured along the valley of about eighteen miles, but following the windings of the stream it is fully twice this distance. It is the outlet of Moose lake, a body of water about eight miles in length occupying a depression in the floor of the old valley.

Russell creek.

Russell creek (Red Slate creek) joins the Macmillan about four miles below the Forks and is important as being the only tributary, so far, on which coarse gold has been found. It heads in a small lake 12 miles north of the Macmillan, and has a total fall of 1,400 feet. It is a rapid stream about 40 feet in width and is fed by a number of impetuous torrents descending from the mountains bordering its valley. The valley of Russell creek is from one to three miles in width and extends through to the Stewart drainage system.

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Recent elevation in this valley is shown by the fact that the present stream has cut in places a canyon in the bottom of the old channel.

Topography—The general character of the country in the vicinity of the Macmillan is mountainous, although the ranges as a rule are isolated by wide valleys and depressions. Below Kalzas river the Macmillan is bordered on the north by the Macmillan mountains; a long ridge with fairly even slopes except near the centre, where it rises about 1,000 feet above the tree line and is broken into a number of rocky peaks, the highest of which has an elevation of about 3,800 above the level of the river or 5,600 feet above the sea. Opposite the Macmillan mountains the country between the Macmillan and the Pelly is occupied by a high plateau-like mass with smooth outlines, the summit of which rises just above tree line to an elevation of about 2,700 feet above the valley. East of this plateau is a wide depression, extending east to Dromedary mountain and south to the Pelly. This depression is faced on the north of the Macmillan by Kalzas mountain and the range connected with it. Kalzas mountain rises 4,300 feet above the valley and is the highest peak along the main Macmillan river. North-east from it, at a distance of ten miles, is Clarks peak, a conspicuous conical mountain, visible from almost every elevation climbed to, along the river.

Mountainous
character of
country.

The region north of the Macmillan, between the valley of Moose river and Russell creek, is occupied by a high broken plateau, deeply trenched by numerous streams flowing into the surrounding valleys. South of the Macmillan the country bordering on the valley, with the exception of a couple of relatively unimportant depressions, is rough and mountainous from Dromedary mountain east to the Forks. The mountains, mountain groups, and broken uplands along the Macmillan valley have a common origin and may be briefly described as representing surviving fragments of an extensive highland, the major portion of which has been destroyed by sub-aerial denudation and erosion.

The North Fork of the Macmillan.

The Macmillan, a few miles above Russell creek, separates into two branches known as the North and South forks. The two branches are nearly equal in size, but the former carries a much larger volume of water. The North fork, although it continues for some miles in the same direction as the main Macmillan and occupies a similar wide flat bottomed valley, differs entirely in character.

Description of
North fork of
Macmillan
river.

It is an exceedingly rapid stream and bears more resemblance to a mountain torrent than to an ordinary river. Between the Forks and Cache creek, a distance of 45 miles, measured along the valley, and

Rapids and current.

about 70 miles following the windings of the river, the valley has a fall of about 18 feet to the mile and the river of about 12 feet to the mile. The current is uniformly swift throughout, running at the rate of from five to eight miles an hour. The channel in places is filled with boulders, and strong riffles are frequent, especially for some miles above and below the mouth of Husky Dog creek, but no strong rapids necessitating portages occur below Cache creek. Two and a half miles above this is the Big Alec rapid, a rough bed rock rapid a quarter of a mile in length. Above this rapid the stream continues very swift as far as examined.

The direction of the North fork is generally a few degrees north of east, except in one stretch 10 miles in length commencing 25 miles above its mouth measuring along the valley. The river at this point enters an old valley running nearly magnetic north and south and follows it north to the mouth of Husky Dog creek, then leaves it abruptly and continues its easterly course. The old valley just referred to extends south to the South fork, and north probably to the Stewart and is occupied in turn by a number of streams along different portions of its course.

Tributaries of North fork.

The principal tributaries of the North fork are Barr, Husky Dog and Cache creeks from the north and Clearwater creek from the south. These streams all carry considerable volumes of water, and occupy deep, wide valleys. Cache creek, the only one examined, has a width of about 50 feet, and a length measured along the valley of 20 miles. The valley of this creek is wider than that of the main stream and extends through to the South fork of the Stewart. The summit is close to the Stewart valley and the drainage is all southward.

Selwyn range.

Topography.—The North fork below Barr creek is bordered on the north by a long ridge and on the south by a high wooded plateau. Six miles above Barr creek the river bends suddenly northward, between two lofty mountain ranges, and for the remainder of its course traverses a continuously mountainous country. The name Selwyn range is proposed by the writer for this group of mountain ranges. The summit range of the Selwyn mountains forms the Yukon-Mackenzie watershed—and the whole group may be considered as one of the sub ranges of the Rocky mountains. The central portion of the range is drained on the west by the North fork of the Macmillan and the South fork of the Stewart and on the east by Gravel river, all large, rapid streams. The north and south limits of the range have not yet been defined.

Description and height of.

Selwyn range differs from the main range of the Rocky mountains further south in consisting of a number of irregular groups

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of mountains and not of a series of parallel longitudinal ridges. This feature is due largely to the presence in the range of several large granite masses, cutting the argillites and cherty rocks of which the mountains are mainly formed. The mountain groups are occasionally separated from each other by wide, low passes connecting the main drainage line. The mountains have a height of from 3,000 to 5,000 feet above the valley, or from 6,000 to 8,000 feet above the sea. Their general appearance is rather subdued, as the argillites and cherts when horizontal, or nearly so, weather into rounded elevations without marked individuality. The sculpturing in the granite areas is, however, bolder and more rugged, and the shattered pinnaced crests which often surmount the ridges of sharply tilted cherts and agglomerates, give variety to the view.

The South Fork of the Macmillan.

The South fork at its entrance to the main river is very unlike the North fork. It is rather wider, having a width of 250 feet; the current is slack for several miles above its mouth, the colour of the water is much darker and the temperature slightly higher than that of the North fork. The stream as far as examined has many of the characteristics of the main river. For the first twenty-five miles following the windings of the stream the average grade is about three feet to the mile, from this to the canyon the grade is probably five feet. The speed of the current varies from two to five miles an hour, with occasional accelerations. Fifty-eight miles from the Forks is a canyon about half a mile in length, the river breaking into three rapids on its course through it. Beyond the canyon the valley widens out, the grade increases and the river runs swiftly around sharp bends and resembles the North fork in character during the remainder of its course.

South fork
Macmillan
river.

The general direction of the South fork is south-easterly, but toward the head it appears to bend to the north, and one of its upper branches heads quite close to those of the North fork. The first tributary stream enters the South fork from the south at a distance of twenty-four miles from the Forks; beyond this are several small streams coming in from both sides. The principal tributary is Riddell river entering from the south, forty-six miles from the Forks. This river is 125 feet wide, the water is of a brown colour, and the current is slack, moving at the rate of about two miles an hour at the lower portion; the grade increases slightly, higher up the stream, with occasional small riffles.

General
direction.

Principal
tributary.

Twenty-six miles above its mouth Riddell river breaks into two branches of about equal volume, the one from the south coming in with

Branches of
Riddell river.

the velocity of a torrent, beyond this the easterly branch is still water for about a mile, then becomes swift and the river from this point onward is impassible with canoes.

Topography.—The valley of the South fork bears such close resemblance, both in grade and cross section, to the main river valley, that it may be regarded as a continuation of the latter.

Probably old
valley.

For about ten miles by the valley above the Forks the South fork is bordered on the south by long ridges of fairly regular outline rising from 500 to 1,200 feet above the valley, these slope gently back from the river banks and are thickly covered with moss and small spruce. Beyond this the ridges become lower and recede from the river, the valley widening out on both sides. Sixteen miles, by the valley, from the Forks is a very pronounced depression to the north of the river. This depression runs through to the North fork, a distance of about eleven miles. The nature of the floor of this valley is concealed by a thick growth of small spruce and a deep covering of moss, but from the absence of rock exposures and the presence of numerous small lakes it is assumed to be an old valley of erosion, partially filled up by deposits of loose material of glacial origin. The floor of this valley rises to a height of 300 feet above the level of the South fork, and to about 170 feet above the North fork.

South fork
mountain.

East of this valley and on both sides of the river are mountain groups, those to the north rise gradually by a series of ridges and culminate in several lofty peaks, which form an important spur of the Selwyn range. The group to the south is known as the South Fork mountain, and bears a rough resemblance to an elevated table land. The watershed of this group is close to the South fork and one of its chief features is the deep channels which the streams have cut in its flanks. Here are seen gorges V-shaped, with walls sometimes 500 feet in height.

Beyond the canyon the valley opens out again and widely isolated groups of high mountains are to be seen in the distance to the east and south, while the intervening country presents a succession of low parallel ridges with even outlines. Riddell river flows through this rolling country, slowly cutting down its bed in sand and gravel deposits.

Terraces.

Terraces, well preserved and continuous, are to be seen in this part of the valley: the highest well marked ones were found at an elevation of 600 feet above the river level, or 3,000 feet above the sea.

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FORESTS.

The principal tree found along the valley of the Macmillan is the Timber-white spruce (*Picea alba*). This tree is found both in the valley bottoms and on the mountain sides to a height of 2,800 feet above the valley at the mouth of the river and 1,800 feet above the valley at Cache creek. Groves of white spruce with trees measuring from one to two feet in diameter occur on most of the river flats and alluvial islands, and in a few localities individuals of this species were seen which measured three feet in diameter. The groves are small as a rule, but the aggregate amount of good spruce timber in the valley is considerable. Among the other trees noticed may be mentioned the black spruce (*Picea nigra*), the aspen (*Populus tremuloides*), the balsam poplar (*Populus balsamifera*), the black pine (*Pinus Murrayana*), the balsam fir (*Abies sulalpina*), and a birch (probably *Betula papyrifera*). The black pine occurs in large groves on the benches along the lower part of the Macmillan valley and was traced eastward for thirty miles beyond the fork. It seldom exceeds nine inches in diameter. The balsam fir occurs mostly on the mountain slopes and was seldom seen on the river flats. It is found all the way to the tree line, but seems to thrive best at an elevation of 1,200 feet above the valley, the trees gradually decreasing in size above and below this elevation. The birch is usually small and not very abundant.

White spruce
and black pine
plentiful.

The forest along the main Macmillan and up both forks for some distance is fairly luxuriant and very similar to that on the Lewis and Upper Yukon. On the upper portion of the North fork the trees are much smaller and more scattered, and the prevalence of white reindeer moss on benches and mountain slopes contribute a sub-arctic character to the landscape.

GEOLOGICAL SECTION ON THE MACMILLAN AND DOWN THE PELLY RIVER.

The Macmillan valley does not afford a good geological section as it is filled with glacial drift and bed rock is seldom exposed. The frequent long gaps in the valley section, rendered necessary an examination of the bordering ridges and mountains, on all of which good exposures were found. Some time was spent on the Pelly below the mouth of the Macmillan, as only a hurried examination of the rocks was made by Dr. Dawson in 1887.

Macmillan
valley filled
with glacial
drift.

Steep mural cliffs of basalt occur along the right bank of the Pelly above its mouth and rounded hills of massive grey biotite granite on the left bank.

Basalt cliffs

The basaltic plateau occupies the angle between the Pelly and the Yukon and extends down the latter river about twelve miles. It has a height of about 520 feet. A typical well-preserved volcanic cone built largely of vesicular basalt occurs a few miles north of the Pelly. The cone has a height of 2,570 feet above the river, and of about 1,000 feet above the general level of the country in its vicinity. The crater in the summit of the cone has a depth of 450 feet and a width at the bottom of 300 feet.

Comparatively recent lava flow.

The last lava flow, now represented by a ridge of basalt fifty feet high, escaped through a break in the encircling wall of the crater and streamed to the eastward. The date of this volcanic cone is comparatively recent as its outlines have not been modified by denudation to any material extent. It is unlikely that all the basalts in the vicinity issued from this cone and it is probable that other vents will be discovered when the country is closely examined. The basalts are replaced four miles up the valley by grey Liotite granite, and the latter, five miles further on, by crystalline schists.

Crystalline schists.

The schists include several varieties, the principal one being a hard quartz-mica schist evidently an altered clastic, garnetiferous schists, chloritic and hornblende schist, and bands of white crystalline limestone. These rocks are associated in places with granite gneisses and evidently represent the Nasina series described in previous reports as occurring on the Yukon and Stewart rivers and in other localities. They have an east and west strike, and outcrop along the river in frequent exposures up to Willow creek, a distance of over twenty miles. East of Willow creek the Pelly winds through a wide depression filled with glacial deposits, and destitute of exposures of older rocks. The depression extends southward along Mica creek, the outlet of Tatlain lake and may be underlain by the Cretaceous coal-bearing rocks which cross the Lewes at the Five Finger rapids. Drift lignite was found on Mica creek, and also on the Pelly below the mouth of this creek.

Granite gneisses similar to those in Yukon valley.

The hills which border the depression, just mentioned, on the north-east consist of sheared granite gneisses similar to those along the Yukon valley, and evidently like them of eruptive origin. They are concealed along the river but outcrop in Knob Hill, north of Willow creek and Ptarmigan mountain, south of Granite canyon and also at one point above Gull rock in Granite canyon where they project up into the andesites.

The granite gneisses are overlaid in the valley of the Pelly for some miles below Granite canyon by andesites, and these rocks form the

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high valley walls in the lower portion of the canyon. The andesite is associated in a couple of places with soft yellowish tuffaceous sandstones and dark carbonaceous shales. The latter at one point near Gull Rock pass into an impure lignite. These carbonaceous beds are probably of the same age as the lignite-bearing beds at Five Finger rapid which hold Cretaceous fossils.

Carbonaceous
shales.

East of Gull Rock, a name given to a sharp splinter of andesite forty feet in height in midchannel, the canyon walls consist largely of volcanic bombs. The upper part of the canyon is cut through coarse gray massive granite. Between the upper end of Granite canyon and the mouth of the Macmillan, the rocks exposed in the valley consist of chlorite and sericite schists passing in one place into an augen gneiss. These rocks resemble the Klondike schists which are known to be, in part at least, of eruptive origin.

Macmillan River Section.

The Macmillan mountains north of the lower part of the Macmillan river consist largely of a quartz schist or feldspathic quartzite, the precise character of which has not been determined. This rock is coarsely schistose, varies in colour from white to black and is jointed at right angles to the bedding planes. It is interbanded with dark argillites, mica schist and crystalline limestone.

Geological
description of
Macmillan
mountains.

A couple of rocky bluffs south of the river, one 1,000 feet in height, are built of white coarsely crystalline limestone containing numerous fragments of crinoid stems, probably indicating Carboniferous age. The limestones overlie chlorite and sericite schists, on which they probably rest unconformably. Several small areas of eruptive rocks—mostly granite and andesite, occur in the Macmillan mountains.

The Macmillan mountain beds have a general N.W. and S.E. strike and dip to the S.W.

They are succeeded and apparently underlain, ascending the river, by hard dark argillites, passing in places into quartzite bands and inclosing occasional beds of limestone. These rocks are well exposed in the southerly slopes of Kalzas mountain, and farther to the east in Lone mountain and the summit of Dromedary mountain. They are cut off at the summit of Kalzas mountain by granite, and are apparently underlain on the north-east by a band of breccias or agglomerates consisting mostly of angular fragments of dark and occasionally green and red cherts, imbedded in a siliceous matrix. The chert breccias form the eastern part of the Kalzas range.

and also outcrop in the lower slopes of Dromedary mountain south of the river.

The chert breccias are followed, apparently in descending order by slates, alternating in places with dark cherts, and then by a great series of tuffs, grits, quartzites and red, green, gray and striped slates and schists. The red slates and associated rocks occur along the Macmillan from a point a few miles above the mouth of Moose river up to the Forks and beyond. They form the greater part of Plateau mountain north of the Macmillan and the Russell mountains east of Russell creek. A wide band of dark brittle cherts interbanded with the red slate series crosses Plateau mountain west of the summit, and massive amygdaloids passing in places into a schist outcrop north of the valley a few miles below the mouth of Russell creek.

The red slate series, like the beds in the lower part of the river, have general north-west and south-east strikes and south-west dips. The attitude of the beds apparently indicate a descending series from the mouth of the Macmillan to the Forks, but the regularity of the dip is probably due in large measure to faults and over turn folds.

Rocks divided
into two
groups.

The rocks along the main Macmillan may be divided tentatively into two great groups. One group consisting of argillites, quartz schists, quartzites, and limestones and the other largely of volcanic fragmental rocks including tuffs, felspathic grits, and red, green, brown and striped schists. The latter group are interbanded with and are overlain by cherts and argillites above which are chert breccias.

Section of the North Fork.

Great thick-
ness of cherts.

Striped and green schists belonging to the red slate series are exposed on the North fork for some miles above its mouth and are then replaced by dark argillites holding occasional beds of limestone. The argillites are less altered than the red schists and associated beds, and the cleavage planes are subordinate to the bedding planes. They are probably the equivalents of the argillites and cherts which overlie the red slate series on the main river above the mouth of Moose river. These argillites have a wide distribution as they are found all along the North fork up to the mouth of Cache creek and on the lower part of Cache creek. Above the mouth of Husky Dog creek they alternate with dark, brittle, flinty beds, which are referred to as cherts, and are largely due to an infiltration of the argillaceous beds by amorphous silica. These cherts occur both in thin beds, and in bands up to a thousand feet or more in thickness. They are the most prominent rock in the Selwyn range.

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The schists and quartzites of the red slate series were noticed at several points along the North fork, especially in the vicinity of the eruptive masses but no large areas were determined.

The argillites and associated cherts are replaced near the head of Cache creek by an alternating series of chert breccias, shales, and dark limestones at least 5,000 feet in thickness. The chert breccias resemble those in the Kalzas range north of the main Macmillan and are apparently a repetition of the same series. The angular chert fragments, the principal constituent of the breccia is precisely similar to the chert beds and bands found lower down the river and are no doubt derived from them.

The North fork section may be summarized as consisting of three sets of beds, viz.: a lower series of red, green, and striped schists, with tuffs and quartzites, a middle series of argillites and cherts, and an upper series of chert breccias and shales.

South Fork Section.

The rocks on the South fork of the main Macmillan are similar to those on the North fork. The red and green schists occur near the mouth, but are soon replaced by argillites and cherts, and the latter twenty miles above the Forks are followed by chert breccias, shales, sandstones and limestones which continue as far as the mouth of Riddell river. Beyond this the rock is principally shale of a compact variety, which becomes hardened and altered near the intrusive masses. The mountains to the north of the river are composed of granite and those to the south of andesite. The latter rock cuts through the shale of the valley at a height of about 1,500 feet above the river.

Rock section
on South fork
of main Mac-
millan.

About eleven miles above the mouth of Riddell river several dykes cut the shales. These dykes harden the latter, which here form the walls of a narrow canyon about half a mile long. The bed rock of Riddell river is a soft, crumbling, black shale with occasional harder beds. The age is uncertain as no fossils were found, but they are probably younger than the chert breccias.

Granites and allied rocks and andesites occur at several points along the Macmillan and its tributaries, but as the specimens have not been examined microscopically only a brief reference will be made to them here. A number of irregularly distributed granite areas occur in the Selwyn range, where they form the central portions of some of the principal mountain groups.

Igneous rocks

The granite is of the usual gray biotite variety, is often strongly jointed and weathers into conspicuous cliffs and bold rocky summits. Areas of granite also occur east of Russell creek, on northern portion of Kalzas mountain, and crossing the Pelly river a few miles below the mouth of the Macmillan.

The South Fork mountains were found by Mr. Keele to be built largely of andesites, and small areas of this rock occur on the Macmillan mountains, and also at the Granite canyon on the Pelly. The andesites are much younger than the granites and at the Granite canyon are associated with lignite-bearing beds of probably Cretaceous age.

General Glacial Features.

Glacial features. During the glacial period a glacier descended the Macmillan river valley from the Selwyn mountains to its mouth and continued down the Pelly river to a point about 20 miles above Fort Selkirk. Glacial groovings and striae occur at a number of places along the bottom of the valley, and on the lower slopes of the mountains bordering the valley up to a height of 1,200 feet. The direction of the ice flow was westerly and coincided very closely with that of the valley. The thickness of the ice, judging from the height at which foreign material was found, was 3,000 feet in the western portion of the Selwyn mountains, 3,300 feet at Dromedary mountain, and 2,000 feet at the Macmillan mountains. The upper surface of the glacier appears to have been nearly level from the Selwyn mountains to Dromedary mountain, the slope being less than that of the present valley, but west of this point the western declination averaged nearly 200 feet to the mile.

Higher peaks of mountains show no trace of glaciation. The ice even in the Selwyn mountains did not cover the higher peaks or, if it did, has left no trace of its presence, and while the valleys and depressions in the broken country to the west were deeply submerged all the principal elevations remained uncovered.

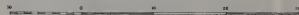
Glacial deposits. Foreign material in the Macmillan mountains is found up to a height of 2,000 feet. Below this elevation the slopes are comparatively smooth, but above it the harder bands of rock often project above the surface in crumbling walls and loose rocky points which show no evidence of ever having been disturbed except by the ordinary agents of sub-aerial denudation.

The deposits of the ice period, consisting of boulder clays, gravels, sands, silts, and clays, are exceedingly irregular in distribution and sequence and evidence rapidly changing conditions along the valley.



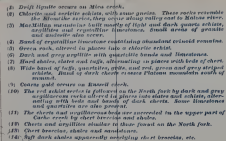
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Scale, 8 statute miles to inch = 200,000.



MAP
of a portion of the
YUKON TERRITORY
Shewing explorations on
MacMillan, Pelly and Stewart Rivers

to illustrate report of
R. G. McCONNELL, B.A.
1902



Y. 809

of a portion of the

Shewing explorations on

to illustrate report of
R.G.McCONNELL, B.A.
1902

Polley and Mike Milman, vicars from Fort Salvo to the All Saints Church to the Middle River on Smith River, Microcomputer Survey of J.R.K., 1982

North Fork Macmillan River and Middle River from truck surveys by M.G.M. Corbett and J.Krue, 1982

General river and topography north of Salvo from survey by J.L.M. Fisher Department of the Interior NMN

The other features adopted from the published reports of the Geological Survey 1987 & 1988

Nights on the Salvo and Middle River

Compilation by J.Krue, 2010

Polley and Mike Milman, vicars from Fort Salvo to the All Saints Church to the Middle River on Smith River, Microcomputer Survey of J.R.K., 1982

North Fork Macmillan River and Middle River from truck surveys by M.G.M. Corbett and J.Krue, 1982

General river and topography north of Salvo from survey by J.L.M. Fisher Department of the Interior NMN

The other features adopted from the published reports of the Geological Survey 1957-62

Nights on the Salvo and Middle River

Compilation by J.Krue, 2d Ed.

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Beds of gravel, evidently deposited by running water, fine silts which have slowly settled down in still water, and glacial boulder clays often alternate several times in the same section.

Boulder clay occurs in disconnected patches all along the Macmillan valley, and down the Pelly for some distance below the junction of the two streams. The heaviest and most continuous deposits of this material noticed occurs on the Pelly river above Mica creek, near the western limit of the glaciated area. Sections at the cut banks along this portion of the river show a bed of typical boulder clay, filled with glaciated boulders, forty feet in thickness. Thick bed of boulder clay.

The upper surface of the boulder clay bed is level and is covered with rolled gravel alternating in places with sand. A layer of large boulders occasionally occurs at the bottom of the gravels.

Besides the main boulder clay bed at the base of the glacial deposits, several smaller beds alternating with silts, sands and gravels are exposed higher up in the face of a steep terrace which follows the river on the north. The section is concealed in places and a complete record could not be obtained. Granite boulders foreign to the locality occur on the hill sides at this point up to a height of 850 feet above the river.

The boulder clay is underlaid in some places by a bed of rolled gravels, but frequently rests directly on the bed rock. It is overlaid as a rule by silts, sands and gravels, inclosing occasional beds of boulder clay. These deposits are exceedingly irregular and their sequence varies in every section examined. The thin silt beds are often folded around irregular patches of coarse gravel of from three to six feet in thickness and in places are sharply flexed and even overthrown. Silt beds peculiarly folded.

The reason for this singular attitude of the silt beds is not clearly understood, as the movement which produced them, if it were movement, did not affect the associated coarse sands and gravels.

It is possible that the folding in some instances was caused by the pressure of ice descending the valley and dragging over the beds, but this explanation does not appear to be of general application. In some cases the appearance of the beds suggested the deposition of the silt beds in quiet water around masses of gravel brought down into the valley by torrential side streams. The peculiar folded character of the silt beds overlying the boulder clay in the Macmillan valley was also noticed in previous explorations on the Teslin, the Lewes and the Stewart.

The boulder clay in the lower part of the Macmillan valley is overlaid by an important clay bed at least 200 feet in thickness. The clay Important clay bed.

is bluish in colour, is indistinctly bedded and is very plastic, rendering it peculiarly liable to slides. The clay is very pure as a rule, but in places appears to pass upwards into a silt. It is overlaid by sands and gravels. The clay bed was traced from the mouth of the Macmillan up the valley for sixty miles, but is not found on the Pelly below the mouth of the Macmillan.

It was evidently deposited in a long narrow lake of considerable depth, probably held in by an ice dam at the mouth of the Macmillan.

The lower slopes of the mountains where it occurs are faintly terraced up to a height of at least 1,500 feet.

The alternating and irregular beds of silts, sands, gravel and boulder clay which form the upper part of the glacial deposits along the Macmillan valley evidence a period of rapid and complex changes, as quiet water, swiftly running streams and ice, are all necessary to explain them. The surface of the narrow valley plain built up by these deposits is always more or less pitted, and in places is formed of a complicated series of interlacing ridges, some of them evidently of moranic origin inclosing pits and basins often fifty feet or more in depth. A section of one of those ridges showed it to consist mainly of coarsely stratified sands and gravels with some soft boulder clay.

The sand and gravel beds possessed a rough anticlinal attitude, corresponding in a general way with the outline of the ridge, but much flatter.

Drift deposits
variable in
thickness.

The thickness of the drift deposits along the Macmillan is variable but usually measures from 400 to 500 feet. Kalzas river, one of the main tributaries is lined with conspicuous terraces up to a height of 900 feet.

Lakes are common throughout the glaciated district. A number of small lakes occupying shallow rock basins occur in the granite ranges of the Selwyn mountains, and the pits and hollows inclosed by the morainic ridges are often partially filled with water.

The larger lakes like Moose lake and Kalzas lake occupy long depressions in the glacial plains, probably produced in some cases at least by the thawing out of masses of ice left behind on the retreat of the main glacier.

Another class of lakes common in all the valleys simply represents abandoned portions of old river channels.

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ECONOMIC GEOLOGY.

The Macmillan river has not so far produced any gold, although it has been more or less prospected along its whole course. Fine colours are present everywhere, but no pay bars, such as have been worked on the Stewart, Pelly and other tributaries of the Yukon, have been discovered. The old quartz-bearing schist and gneiss which contribute the gold to these streams are replaced in the valley of the Macmillan by younger formations, none of which have proved to be notably auriferous.

Macmillan
river not gold
producing.

The most promising formations for minerals of economic value are the quartz schists and accompanying chlorite, and sericite schists near the mouth of the river and the wide band of red, green and dark schists and associated rocks which crosses the valley in a diagonal direction at the Forks and extends up and down the river for a considerable distance. Both these formations are cut by occasional quartz veins and silicified zones, but the few specimens collected proved on analysis to be barren. Argillites heavily impregnated with pyrite occur in Lone mountain and also in Dromedary mountain. Specimens were analysed but yielded nothing of value.

The only tributary of the Macmillan on which coarse gold has been definitely reported is Russell creek. This stream enters the Macmillan from the north, four miles below the Forks, and cuts through the red schist series referred to above along its whole course. A mining concession embracing the larger part of the main valley has been granted to a company, but no work was in progress during the past season and no definite information in regard to values was obtainable. Some prospecting was done above and below the concession during the season, the results of which were not considered favourable, although fine colours and an occasional coarse colour were obtained.

Gold reported
on Russell
creek.

Russell creek occupies a wide heavily glaciated valley, floored especially in the lower part with heavy deposits of silts, sands and gravels mostly of glacial origin. This drift material thins out gradually ascending the valley, and near the summit the bare rocky floor of the old valley bottom is often uncovered. The present stream occupies a narrow depression sunk through the drift deposits down into the bed rock beneath. The grade of the stream is heavy, averaging 100 feet to the mile, the flow of water in the main stream and also in some of the steep tributaries is ample for hydraulicing at all seasons and the conditions are generally favourable for cheap working. The prospecting done up to the present time has proved the presence of coarse gold in the creek, but has done little more. The extent of the auriferous gravels and their average tenor still remains to be determined.

Favourable
conditions for
working.

Being necessary to prove existence of lignite beds.

A small seam of carbonaceous shale or impure lignite, of no value, occurs at Granite canyon on the Pelly, and drift lignite, as stated on a previous page, was found on Mica creek. It is highly probable that lignite-bearing beds underlie the comparatively low country along Mica creek, but, as no surface exposures were seen, definite information on this point can only be obtained by boring.

A shaft sunk on an easterly branch of Mica creek, about eight miles from the Pelly, is reported to have passed through several small seams of lignite.

THE CLIMATE AND FLORA OF THE YUKON DISTRICT.

Professor John Macoun.

Work done by botanical branch.

During the past year, the routine work of my office has continued to increase and much of my time has been employed in determining specimens and replying to queries from working naturalists throughout the Dominion. During the winter and early spring months, the proofs of Part VII. of the Catalogue of Canadian Plants were read and revised and this report was printed before my departure for the field in June.

I am now completing the manuscript of the second part of my Catalogue of Canadian Birds, which will be printed this winter. In conjunction with Dr. Theodor Holm and James M. Macoun a flora of the Hudson Bay region has been written, which will be published next autumn. In the office work I have been assisted by Mr. James M. Macoun and Miss Stewart. The time of the former has been chiefly employed in determining specimens, while Miss Stewart has been engaged in writing labels and filing letters.

Specimens sent for determination.

A record has been kept of the number of specimens sent for determination to my assistant or myself, and, without including the collections brought in by members of the Geological Survey staff, these number 1,644 sheets of specimens. The largest of these collections were from Anticosti (375 specimens) and St. Laurent college (314 specimens), while smaller lots were received from all parts of the Dominion. My own collections, made in the Yukon, number many specimens, many of the species being new to science. These are as yet undescribed. Mr. James M. Macoun brought from southern British Columbia a very large collection of plants, birds and mammals upon which he is now working.

Since the last summary report was published 3,226 sheets of specimens have been mounted and placed in our herbarium.

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Of these 1,858 were Canadian flowering plants, 927 were foreign and 441 were cryptogams; 3,461 specimens were distributed from the herbarium, chiefly in exchange for specimens received in previous years. One hundred specimens were purchased and 832 were received from foreign correspondents.

Miss Stewart, our clerical assistant, has during the year spent a portion of her time assisting the librarian. In addition to her work before referred to she has completed the numbering of the herbarium sheets of flowering plants, of which we have 57,961; of these 34,289 are Canadian.

Reports on the character of the country and the climate in the vicinity of Dawson, Yukon district, differed so much from one another and were so contradictory that I was instructed to make an examination of the Klondike district during the summer. I made the necessary preparations and left Ottawa on June 27. On my arrival in Vancouver, I waited two days for a boat, and on the morning of July 5, left for Skagway on the steamer *Anaw*. At 10 p.m. on the 7th I reached Skagway and left the next morning for White Horse, reaching there at 4.30 p.m. At 8 p.m. the same evening I took the boat for Dawson and reached that city at 8 a.m. on the morning of the 10th.

Examination
of Klondike
country.

Work was commenced the same day and I collected specimens and made notes in the vicinity of Dawson until July 21, when I went up Hunker creek and examined the country for miles around. I remained there until August 3 when I returned to Dawson. After a few days I took the stage to Gold Run creek, a distance of forty-eight miles. The road passes up Bonanza creek and over the Klondike—Indian divide, and then down Gold Run creek to Dominion creek. This trip enabled me to see a large section of the country and assisted me very much in my final opinions regarding it.

Work in the
vicinity of
Dawson.

By the last week in August I saw my work for the season accomplished and started on my return to Ottawa on August 25. On my way up the river I purposed stopping at Fort Selkirk, but, owing to a severe cold, I was forced to push on to White Horse which I reached on the 29th. Four days were spent at White Horse and then I proceeded to Skagway and finally reached Ottawa on September 15.

The day has passed when the trip to Dawson means either difficulty or danger above the ordinary, but the element of time is still considerable. If close connections were made, the trip to Dawson would require only ten days and the return trip thirteen days.

Description of the route from the White Pass to Dawson.

Cross White
Pass.

We crossed the summit of the White Pass at an altitude of 2,952 feet and began to descend at once to the north. Here we were above the tree line, and bare mountain slopes, broken rocks, pools of water and a truly arctic or high mountain vegetation showed the climate to be cold, while the stunted and broken trees lower down indicated the immense snowfall which is characteristic of the whole coast range.

As we descended towards Lake Bennett the vegetation rapidly changed and stunted firs (*Abies amabilis*) gave place to small spruce trees and the high mountain shrubs and herbaceous plants began to be replaced by forest species. Little time was available for making collections, but the species collected were those found at an altitude of 6,000 feet in the Selkirk mountains. At the head of Lake Bennett, where we had lunch at 2,170 feet altitude, an agreeable change was noticeable and the vegetation had much improved. The mountain summits, however, showed that we were not far below a chilly atmosphere.

Railway
follows east
side of Lake
Bennett.

The railway keeps to the right or east side of Lake Bennett and a very little below Bennett station takes a slight turn to the east. The cold winds from both the Chilcat and Chilcoot passes seem to be cut off and a most astonishing change takes place in the vegetation. Our train reached the point where the trains cross, some time ahead of the train from the west, and quite a collection of plants was made and numerous species indicating a mild climate were obtained. Amongst them a species of rose (*Rosa acicularis*) was found in bud. Two days later the same species was gathered, with fruit half grown, at Dawson four degrees farther north.

Fine climate
at Caribou
Crossing.

At Caribou Crossing, 24 miles from Bennett, without descending one foot, the whole vegetation had changed and everything indicated a genial climate. Since then I have learned that next year farming on an extensive scale is to be inaugurated at this point. It is true that the soil is light sandy loam at the crossing, but it is said to be better eastward along the lake.

Gardening
successful.

The general character of the valleys from Caribou Crossing to White Horse varies little, but there is a gradual change of climate as indicated by the vegetation. There is evidently less rainfall and, outside of the river valley, more sand. Although I reached White Horse in Lat. 60° on the 8th July, I found the wild flowers past their prime and asters and golden rods, that would not flower in Ontario until August, were beginning to ripen. This was a new town a year since, yet attention has already been given to gardening by the steamboat owners.

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Although White Horse is very far south of Dawson, its climate is far from being as good as that of Dawson, but the past summer all who have tried have been successful in bringing vegetables to maturity. When there in September, arrangements were being made for more extensive cultivation next year.

The character of the forest along the Yukon varies according to locality. The trees vary greatly in size and in no case can the forest be called heavy. There are many groves in the river valley where the trees are tall and stand pretty close together. These are the exception, however. In general the trees are under a foot in diameter but many run to 20 inches. On the slopes near the river they are generally small and not so tall as in the river valley.

Nature of
forests.

Back from the river occasional glimpses were obtained of wooded slopes which seemed to have a covering of fair sized trees. As no stoppages were made except to take on wood, there was no chance to see anything except from the deck of the steamer. The forests along the Yukon cannot be compared with those of any other region because they exist under different conditions. The Yukon flows from south to north with a tendency to the west. This gives almost constant sunshine on the east or right bank of the river and hence many of the cliffs and mountain slopes are covered with grass. Often for miles only scattered trees can be seen on this side of the river. On the left bank everything is changed. Here the steep slopes have small trees but where the slopes are less abrupt and more exposed to the sun the trees stand closer together and are apparently much larger. This may be said to be the general character of the river banks all the way from White Horse to Dawson.

At White Horse the forest outside the river valley is composed of lodge-pole pine (*Pinus Murrayana*), but in the valley from there to Dawson black and white spruce are the prevailing trees. White spruce is the chief wood used on steamboats, and indeed for every purpose except as firewood at the mines, where black spruce and birch (*Betula resinifera*) are largely used. Aspen poplar and balsam poplar are common throughout the country. The latter with willows constitutes the woody vegetation of all but the very oldest islands in the Yukon. On the latter large white spruce trees are often seen standing up straight and tall. The forest in the immediate valley of the Yukon will soon disappear, as many thousand cords are used every year by the steamboats, and rafts are floated to Dawson to be cut up for firewood.

Prevailing
trees.

On my arrival at Dawson on July 10, I took notes of the condition of vegetation at that time, and was struck with the advance already made by the native plants and shrubs. Garden strawberries were that day placed on the market at \$2.50 per box.

Situation of
Dawson.

The first thing that strikes a traveller when he reaches Dawson is its situation. It takes up the whole of a swamp which extends from the mouth of the Klondike to where Moosehide mountain impinges on the Yukon, a mile below. The city is on the right or east bank of the Yukon, which here is about as wide as the Ottawa at the capital, with a current of four or five miles an hour. The city crosses the swamp, and many cabins are built on the mountain side for over 500 feet up its slope.

Drains have been dug along all the streets and surface drains about two feet deep on many of the unoccupied lots. Gradually the frost is passing out of the ground, as many of the houses show that the ground is settling. Attempts have been made in numerous places to make lawns, and although in most cases very little work has been done, timothy has taken well and the lawns of the Presbyterian church and the hospital are growing rapidly, and, after being cut, spring up quickly.

Rapid growth
of vegetation
due to long
summer days.

On Sunday, July 13, nasturtiums and sweet peas were in flower and on the next day an eastern rose bloomed in the garden of Dr. Brown the Territorial Secretary. Owing to the long days of late May and all June, vegetation grows very rapidly, and I was surprised on my first trip up the mountain on the 11th July to see that, even then, most of the flowers had perfected their seeds, though many were still blooming profusely. Roses were long past flowering and their hips were colouring. At about the same altitude, only four days before, I found the same species of rose coming into bloom on the shore of Lake Bennett, over four degrees or 300 miles farther south. The species was *Rosa acicularis*, and Mr. James W. Tyrrell showed me specimens he had gathered in flower on June 2. Last spring Dr. Guillet of Ottawa and myself had been noting the flowering of all species at Ottawa, and this species was first detected in flower in Queen's park, Aylmer, Que., nine miles from Ottawa, on June 3. This one simple fact shows the progress of the spring at Dawson better than a whole series of elaborate statistics, because statistics do not give the amount of heat and light given out in a 20-22 hours day,

On the 12th I collected plants on the mountain and gathered red currants (*Ribes rubrum*), blueberries (*Vaccinium uliginosum*) and mountain bearberries (*Arctostaphylos alpina*) in profusion, fully ripe. Hosts of other plants were in seed and *Anemone parviflora* was blooming the second time. The fruit of the 'prairie crocus' (*Anemone Nuttalliana*) had all fallen and the leaves turned to dust. Every native plant seemed to have almost completed its summer's work at this time. I could find no plants that indicated coldness, so on the

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14th I ascended Moosehide mountain immediately in rear of Dawson to see if there were any on it.

Dawson is 1,200 feet above the sea and Moosehide mountain rises 2,050 feet above city. The mountain as seen from Dawson throws out two long ridges, one towards the Klondike, the other towards the Yukon below Dawson. Both ridges end in steep cliffs facing the above rivers. Paths from many points in Dawson lead to the summit of the Klondike ridge and from there other paths lead to the summit.

Ascend
Moosehide
mountain.

On Monday, July 14, I made my first ascent of the mountain and particularly noted the vegetation. There were many fine species on the lower slope either in flower or seed and intermixed with these were grasses of the genera *Arctagrostis*, *Poa*, *Festuca*, *Calamagrostis*, and *Trisetum* and *Agrostis* were represented by a single species each. Later I found that these were the commoner grasses of the country.

An umbelliferous plant discovered by Dr. G. M. Dawson in 1887 and named in his honour grew from base to summit. The plant in question is *Selinum Dawsoni*. The Carices were altogether eastern and ascended to 3,000 feet on the slope. Pale corydalis (*Corydalis glauca*) was abundant on burnt land and the western form of *Corydalis aurea* was occasionally seen. The great willow herb (*Epilobium spicatum*) was in profusion everywhere and indeed is the common fire weed of the Yukon as it is in British Columbia and the east.

Vegetation
noted.

Aspen poplar (*Populus tremuloides*) was abundant, white spruce (*Picea alba*) covered all the dry slopes, and the black spruce (*Picea nigra*) was everywhere else, including all swamps and slopes facing north at any altitude. After climbing about 1,000 feet above Dawson, an alder (*Alnus fruticosa*) taking a tree form was not uncommon. Another common tree was a birch (*Betula resinifera*) which averages about six inches in diameter and is much used in Dawson for firewood.

Forest trees.

As I ascended higher, many other species of plants came in, but a species of *Polemonium* occupied more ground than all the others put together. Another prominent and beautiful species was a golden-rod (*Solidago oreophila*) which is characteristic of the Yukon and extends to White Horse. At about 2,000 feet altitude, the flora changes and *Saxifraga tricuspidata* and *reflexa*, *Arenaria lancifolia* and other species make their appearance. About 500 feet higher up, the same species were found in seed and everything else indicated more warmth than was evidenced by the development of the vegetation lower down. Speaking of this fact later in the summer and deducing from it that the air was constantly warmer 1,000 feet above Dawson in the summer than in the city, I was informed that this was specially true in the winter as it was a common occurrence for parties to go up the

Evidence of
higher tem-
perature 1,000
feet above
Dawson.

mountain in winter to get warm. These statements taken together will be referred to again in this report.

Plants found
on extreme
summit of
Moosehide
Mountain.

On the extreme summit *Potentilla nivea* was in seed and around were *Cetraria nivalis* and *cuculata* and rock lichens that are found at Banff in the Rocky Mountains. Coming down I collected a fine aconite (*Aconitum delphinifolium*) and a larkspur (*Delphinium glaucum*) and noted many species not hitherto seen. A large perennial species of *Polygonum*, looking much like buckwheat, grew in many places and was quite showy with its tall branching stem (about five feet high) and its long racemes of white flowers.

A very extensive view to the east is obtained from the mountain summit, and I was extremely surprised that the Ogilvie mountains which lay, beyond a wide plain, about 40 miles off, were altogether without snow except small patches lying in deep hollows. Although their summits were at least 8,000 feet above the sea, they were entirely bare. This panorama of mountain and plain without a sign of cold in lat. 64° 15', set my mind to work to find out why this could be, and I have solved the riddle to my satisfaction in my paragraph on climate.

Vegetables
grown success-
fully.

The 15th was spent in the Klondike valley and here also new revelations awaited me. The islands in the river have been cleared of brush and trees and in their stead gardens have been established in which vegetables of all kinds come to perfection. From these gardens the citizens of Dawson are supplied with rhubarb, radishes, lettuce, onions, turnips, beans, parsnips, carrots, peas, cabbage, cauliflower, Scotch kale and many other pot-herbs. Everything was in an advanced stage and gave certain promise of a large crop.

All the above vegetables have passed the experimental stage and nothing is necessary to success but care in the cultivation. Collections were made in the valley and many interesting plants were obtained which will be brought out with more prominence in another report.

Next day, July 16th, I crossed the Yukon by the ferry and visited the gardens and farm in West Dawson. The gardens are on the flat along the Yukon, and seem to have been established before any others in the district. Everything was in a forward state for the season. Munro's farm is on a hill about 300 feet above the river and about a mile west of the gardens by the river. Here was actual farming, and, besides the usual garden vegetables, there were at least 25 acres of oats which had been sown for fodder. To the north of the oat fields 25 acres were cleared and were being broken up for a summer-fallow.

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On August 6 I again visited this farm and found a marked change in the growth of the oats. Some of the seed had been sown late and some early, but the greater part late and on freshly broken ground. As a result of this the crop was patchy and tall and short grain grew in close proximity. The land ploughed the year before produced the earliest and best growth of straw. Nearly all the grain was in the milk, but where there evidently had been a crop last year I pulled up specimens of wheat, barley and oats that were far advanced towards maturity. Fine specimens of oats were gathered that were colouring and had very remarkable grain. Instead of one full grain and an abortive one in the fascicle there were always two and often three. This condition I had never seen before, but it seems to be universal at Dawson, as later I noticed it in other fields.

Visits paid to Munro's farm.

On August 23rd I again visited Munro's farm in West Dawson. He was then cutting his oats for fodder. In his latest oats the volunteer barley was all ripe and this was not sowed until June 5th. In this case the barley ripened in 79 days. Tables in my possession show that there is no frost from May 23 to August 23, or 91 days.

Barley ripe in 79 days.

After collecting and making notes around Dawson until July 22nd, I removed to Hunker creek near Gold Bottom creek. From this as a centre I examined the country for several miles around, and learned many things that I had not clearly understood before. Many opinions are expressed regarding the deposition of gold, the depth of the frost in the ground, the occurrence of fossil bones in the gravel and other matters that it is not my province to discuss in this place.

The earlier reports led me to think that the whole country was covered with a thick coating of moss, and that beneath there was permanent frost. Other reports were that there was no wood of any account in the country and scarcely any at Dawson. All these statements were partly true but so far from the whole truth that they were virtually untruths. During the two weeks I spent on the creeks I made a special study of the prevailing conditions and am able to give a clearer view of the situation than I had when I went there.

Earlier reports misleading.

Owing to the high latitude of Dawson, $64^{\circ} 15'$ north, the altitude of the sun above the horizon is never very great. For nearly three months, however, there is scarcely any darkness and the sun is above the horizon over three-fourths of the time. The rainfall and snowfall are both light. This light deposition combined with so much sunshine gives much warmth, and on exposed soil great evaporation. These conditions are so varied that while on one side of a creek there may be two or

Conditions very varied.

more feet of moss and beneath that permanent frost, on the other side the soil may be so exposed to the sun that no moss can exist and only the deepest rooting grasses can maintain a foothold. Hence, people talking about deep mosses speak of land facing the north, while those who claim irrigation is necessary have in their minds trenches exposed to the sun. This being the case any one writing on the subject of vegetable growth or the production of crops must take all the circumstances into consideration.

It must be borne in mind that in the vicinity of the Yukon and its tributary streams there is no level land except in the immediate valleys of the rivers, and these are largely swamps. All the mountains are dome-shaped and the ridges that connect them are narrow with sloping sides. The hills are small replica of the mountains, and the sides of all the creek valleys are sloping and not a precipice is to be seen in the country except along the Yukon or Klondike.

Coating of moss causes permanent frost in ground.

In nearly all cases the lower slopes of the creeks, especially close to the water, are covered with a deep coating of moss, and the valley itself a peat bog chiefly *Sphagnum*. The cause of this is not far to seek. Much of the surface is more or less covered with gravel and the melting snow and rain sink into the soil until the frost is reached when it either changes to ice or runs on the surface of the frozen ground down the slope and oozes out at the base as a series of 'springs,' the thickness of the moss covering generally determining the extent of the summer thaw. Where real springs ooze out in the valleys or on the slopes, the water freezes into what the miners call 'glaciers,' but these are just the water of the springs turned to ice. This condition has a tendency to increase the depth of the frost as an ice sheet under the moss acts like an ice blanket and keeps out the heat. With these facts in mind any person can see that the cutting down of the forest and the drying up or burning of the moss will completely change the conditions, and permanent frost will not be a noticeable factor in the climate of the Yukon.

Timber small in valleys and lower slopes.

By the above it will be seen that in the creek valleys and on the lower slopes the timber must be very small, which is the case. As we ascend the slope, the trees get larger and taller and at an altitude of nearly 2,000 feet above Dawson the forest assumes the appearance of an eastern one, and trees can be found 20 inches in diameter, with trunks nearly a foot in diameter from 50 to 70 feet from the stump. Trees of this character were found at the head of Gold Run creek and its tributaries. It must not be understood that the forests on the Yukon in the vicinity of Dawson are in any sense like those in eastern Canada. The trees are seldom close together, are generally under 50 feet in height, and it is only under exceptional conditions

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that they attain the size mentioned on the preceding page. Much of the timber consists of poles ranging from four to eight inches, the latter size being in the minority. The wood on Hunker creek was of this character and seldom produced two sixteen-foot sticks, into which lengths all cordwood is cut. Before I left Dawson thousands of cords of spruce in sixteen-foot lengths were floated down the Klondike for use at Dawson. These sticks ranged from four inches to a foot or more in diameter, were clean and well grown, and split as straight as a shingle.

The forest in the district visited consisted of eleven species which attain the dimensions of trees but of all these only the white spruce (*Picea alba*) and balsam poplar (*Populus balsamifera*) grew to a considerable size. Black spruce (*Picea nigra*) was abundant in all peat bogs and on the lower slopes of the hills but never became large. Mixed with the black and white spruce were three species of birch, two of which were mere poles, but the third, (*Betula resinifera*), was sometimes eight inches in diameter and supplied most of the firewood consumed around the mines. It was never tall, seldom having a trunk that produced two sixteen-foot lengths for firewood. Three willows and two alders became little trees but were of no use for firewood. Aspen poplar (*Populus tremuloides*) as usual occupied the dry slopes and was mixed almost everywhere with white spruce but was always of small size.

Forest represented by eleven species.

In the Klondike valley about four miles from Dawson, near the mouth of Bear creek, there were a few groves of tall, straight, well-grown balsam poplar and white spruce. These as remnants of an earlier forest showed that the climate was well suited for forest growth, and that the short warm summer with continuous growth gave shapely trees and rapid increase in size.

Attention was given to so many things that in a summary report all can scarcely be enumerated, much less dwelt upon. From what I saw of growing crops I am satisfied that the soils are good. That in the river bottoms was alluvium, overlying the river gravels. On the hills the soils seemed to be chiefly loams, with sometimes sand in greater or less proportion. As no glacier action had taken place the soils were very local in character and largely resulted from the disintegration of the rocks of the locality.

Soils evidently good.

All attempts at cultivation were apparently successful even in the Dawson swamp. When the ground is properly worked, the soil mixed, and the ice or frost stratum in late summer is found at a depth of eight or ten feet, there will be a complete revolution and all crops will mature much earlier. I took notes, during the seven weeks I was at Dawson, of the growth of all cultivated grains and vegetables, and

Cultivation will result in earlier ripening of crops.

below will be found my remarks written at the time. Everything, be it native or exotic, grew surprisingly, and while I never found any cultivated thing a failure, I must say the same of weeds. In every case they were a success and numbers of them were natives of California.

White clover, alsine and red clover as well as timothy grew wonderfully well by roadsides and on dry soil. In the swamp muck of Dawson, much of the clover on lawns, sowed in the swampy soil, looked yellow and had a sickly appearance. Timothy acts similarly: when sowed in the bog it is sickly and yellow-looking, while along dry roads in the woods or on the hillsides it is quite tall and has a seed-head from two to three inches in length.

Yukon district
well suited for
growing
barley.

Barley is certainly well suited to the Yukon district. On August 6th, on the farm at West Dawson, I found grain quite hard mixed with oats that were much later in appearance. On the 18th August, I visited the gardens in West Dawson along the Yukon and found oats being cut for fodder. Mixed with the oats were many barley heads fully ripe and others that had hard grain. In all cases the grain was large. West Dawson was again visited on 23rd August and Munro was then cutting his oats for fodder. In his latest oats the volunteer barley was all ripe and this was not sowed until June 5 so that the ripening of barley at Dawson is an assured fact.

Oats do well everywhere but are seldom even a fair crop on ground just broken up and then seeded. In all cases I found good oats where sown on second year cultivation. The grain was earlier, taller and better in every way. On August 6th I found self-sown oats on Munro's farm in West Dawson fit to cut, but only a few bunches on dry ground. Barley was ripe at the same time under the same conditions. This showed me that up to that date there had been enough heat to ripen oats and barley if sown early on dry soil. Mr. Munro seemed to realize this for on August 23 he showed me 21 acres about ready for a crop, that he had already ploughed three times and intended to sow at the earliest possible moment in the spring of 1903. One man of this type will do much for the Yukon, yet hitherto cultivation of the land on a large scale has been almost prohibited by the local authorities, and, up to the time I left, farming was almost illegal as the gold seekers had blanketed the whole country.

Farming not
in favour.

On my last visit to Munro's farm I advised him to lay his case before the Deputy Minister and, if he did, I am sure that farming in the Yukon will be no longer under disadvantages. There is no reason why all the oats, barley and fodder of all kinds with every vegetable

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required in the home should not be grown around Dawson. That this is not so is the fault of local or other laws that give no surface rights to the individual outside of mining rights. Amending the land laws and giving proper encouragement to farming operations will soon place the Yukon district on a basis where it will be self-supporting outside of wheat requirements.

In the matter of wheat, I do not speak positively, but I believe that after a few years wheat will ripen on all fairly warm soils, although at present its ripening is doubtful. As far as my investigation went I could find no person who had sown wheat. Mr. Munro had sowed oats grown somewhere in the United States, and he informed me that he was led to believe that the wheat mixed with it was spring wheat. Instead it nearly all turned out to be fall wheat and only made leaves, stooled out and its roots penetrated the soil to a remarkable depth and so remained when I saw it on August 23. That it will ripen next summer is to me a certainty, and I trust Mr. Munro has not ploughed it all under. Of the spring wheat I may say it was generally taller than the oats but scarcely as ripe. All the ears were filled to the tip with grain, and the grain was filled out and since has hardened so as to give the appearance of ripe grain. Since my return to Ottawa I have had the grain tested, and the report on the Yukon wheat received from the grain tester Mr. Ellis of the Experimental Farm, is as follows: 100 grains planted; 100 grains germinated; 100 grains made vigorous growth. Germinations very quick and growth exceptionally good.

Wheat growing at present uncertain.

When grain ripens in the country and is again sowed there, it will take on the conditions of its environment and mature earlier, and early frosts, like those formerly attributed to Manitoba, will have no effect as the crop will mature before they come. I may remark here that the wheat in the North-west ripens earlier now than it did twenty years ago and many people believe it is the climate that has changed whereas it is only the wheat that has adapted itself to its environment.

Hitherto potatoes have not been up to the standard as regards dryness and general fitness for the table. After making full inquiry into the subject I became convinced that the seed potatoes came from too far south. Acting on this thought, I had a few pounds of early potatoes sent out to Mr. J. B. Tyrrell with instructions to give them to any parties who would give them a fair chance. I have no doubt of their success. I may say here that Mr. Tyrrell did all he could to make my work a success and in many ways helped me by advice and assistance.

Potatoes not so far grown to advantage.

Growth of vegetables is so rapid and vigorous that to a person coming from the east it is simply astounding. When I reached Dawson

On July 10, early cabbages were being cut and on August 5 their weight ranged from 3 to 5 lbs. On the 22nd, when I made my last visit, hundreds of matured cabbages and cauliflowers had been cut and sold. I measured the two lower leaves of a cabbage cut the day before and the two placed opposite each other had an expansion of 3 feet 9 inches with a breadth of 16 inches. I cannot call this even an average one as there were hundreds larger but later in maturing. Cauliflowers were from six to ten inches in diameter but I was told larger ones had been cut.

No doubt the constant daylight gives the force necessary to expand the vegetative organs of the vegetables in cultivation, but behind the long day are climatic conditions that as yet are little understood which in my opinion are the prevailing factor in this wonderful growth. Dr. Dawson in his geological report on this district indicated that there was little if any boulder clay on the Lower Pelly or Lewes rivers. Since then other reports have more than confirmed his statements, and my own observations tending that way have forced me to adopt new views regarding the past and present of the country.

Cause of
glaciers.

One article of an eastern geologist's belief is that of an ice cap that covered the greater part of the American continent down to the 40th parallel. At Dawson in latitude $64^{\circ} 15'$ and both north and south of it on the highest mountains there never has been glacier ice, yet the winter at present continues from early October to late April. Glaciers, no matter where they are found are produced from one cause, which is greater deposition of snow than the sun has power to melt. As there is no evidence that glaciers have ever existed in this region, it follows that the snowfall has never been great. Mr. Stupart has kindly furnished me with an abstract of meteorological observations during the past three years and I find that there is an average of only nine inches of rain and sixty-five of snow each year. The cause of this light deposition was the next climatological factor and a study of the map of the Pacific coast revealed the undoubted cause.

Any one sailing from Vancouver to Skagway is soon aware after leaving Vancouver island, that there is a marked change taking place in the climate. After crossing Queen Charlotte sound, fog and rain are the prevailing characteristics in the summer, while in the winter they are snow, rain and fog. On the mountains over 5,000 feet, the deposition is chiefly snow. The snowfall being greater than the sun can melt descends toward the sea in valleys often filling them to a great depth and taking the form of glaciers which descend to the sea. Passing north of Sitka, the tourist soon sees the immense glaciers that descend from the Mount St. Elias range. Here Mount Fairweather, 15,287 feet high, Mount Logan, 19,539 feet, and Mount St. Elias, 17,978 feet high

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stand in plain sight from the sea and the observer turns away with the certainty that a country whose sea border is nothing but ice and snow can be of little value so far north. Up to a very late date the whole Yukon valley has been considered of this character and the early explorers with their highly coloured accounts of their winter experiences tended to confirm it.

Instead of the coast range being an injury to the interior, it makes the climate pleasant both in summer and winter. The Yukon district has two climates, a wet and cold one on the coast which may be called the Alaskan climate as nearly all the coast region belongs to the United States. The climate of the Yukon district in Canada is just the reverse, being dry and warm in summer and cold in winter with a light snowfall. Owing to the moisture rising from the warm Japanese current being carried inland by the upper south-west air current and striking the coast range this moisture is at once precipitated on the sea face of these mountains in the form of rain or snow and the air freed from its moisture descends on the Yukon plain as dry air and having an increased temperature. It follows that the rainfall must be light in summer and the snowfall in winter. In another place I show that this is so from Mr. Stupart's report.

The result of the light snowfall is an early spring in the whole Yukon valley including part of Alaska. Then the long day begins to assert itself and by the end of April, growth has commenced, and early in May the Yukon summer is fairly under way. So little rain falls in early spring that many residents asserted that irrigation was necessary to successful growth in certain localities. I do not believe in the necessity of this as the frost in the ground prevents the melted snow from penetrating the soil and keeps it near the surface. I can believe, however, in the necessity of irrigation if the gardener or farmer has waited a month after the snow is gone before sowing his seed. I have always recommended early sowing in northern regions, as growth always comes quickly after the snow has disappeared. The past season I saw oats that were sowed on June 5, that could have been sowed a month earlier if the climate had been considered. All these matters will right themselves in time but the climate must not be blamed for the ignorance of the cultivator.

Instead of the frost being an injury to the country it is a great benefit. A rainfall of twelve inches (snow and rain) means an arid climate and hence little growth. The severe frost being permanent or otherwise retains the moisture and from early spring to late summer the capillary attraction in the soil keeps the roots supplied with moisture and the constant daylight with an unclouded sun gives a vigour to vegetable

growth at Dawson that is never seen in the east. This constant growth brings all vegetables, berries and cereals to early perfection. It was with the utmost surprise that I found red currants and blueberries fully ripe on July 11 and many flowers with ripe seeds, and by the middle of August the trees and shrubs had perfected their wood and were ready for winter. Mr. Stupart's report on the Dawson climate, which is appended to this report, shows that on an average there is no frost from May 23 to August 23, or a period of 92 days, that the temperature rises to 70° or over for 46 days, or for half the period the temperature is 70° or over. Below I give a short table of the temperatures at Dawson and Ottawa for the months of May, June, July and August for the year 1900. The extract is taken from the Meteorological Report for 1902.

Table of temperatures from Meteorological report.

Ottawa, Lat. 45° 26' ; Alt. 294 feet.

May.....	84.8	27.0	53.3
June.....	85.8	46.0	66.6
July.....	87.8	48.0	68.9
August.....	88.8	49.0	69.2

Winnipeg, Lat. 49° 53' ; Alt. 760 feet.

May.....	91.5	14.0	57.3
June.....	100.5	33.0	66.3
July.....	86.2	41.0	64.9
August.....	88.2	45.0	67.4

Calgary, Lat. 51° 2' ; Alt. 3,389 feet.

May.....	79.0	28.0	51.8
June.....	92.0	30.0	57.6
July.....	85.0	36.0	58.2
August.....	90.0	30.0	55.1

Dawson, Lat. 64° 15' ; Alt. 1,200 feet.

May.....	67.3	22.7	46.6
June.....	87.6	36.4	57.2
July.....	85.9	41.1	61.1
August.....	81.3	39.0	53.1

The above are the four growing months everywhere in our climate and the most sceptical must admit that leaving out bright sunshine and length of day Dawson makes a wonderful showing. With these two factors added we are quite safe in predicting a great future for the Yukon district as a producer of everything needed to support a very large population.

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With the facts learned last season and my former knowledge of the Peace River country, the Mackenzie River valley, and northern British Columbia, I am quite within the mark when I say that all the land having a suitable soil within this immense area will in the future produce enormous crops of all the cereals, wheat included. It is well within the memory of us all that growing wheat was for many years considered a doubtful matter at Edmonton and Little Slave lake. These points have passed the experimental stage and now good crops of wheat are secured every year. Two factors combine to make this success. The wheat itself is gradually conforming to its environment and ripening earlier, and local frosts are becoming rarer as the land comes more under the plough. The same changes will take place farther to the north and when wheat is grown as winter wheat and can start at once after the snow is off it is hard to state how far this may be, at any rate as far as Dawson in latitude $64^{\circ} 15'$ where we know there are three months without frost.

A large grain producing area.

Mr. R. F. Stupart reports as follows on the climate of Dawson :—

CLIMATE OF DAWSON, YUKON.

A somewhat broken series of observations at Dawson and various other places in Yukon Territory between 1895 and 1898, and a continuous series at Dawson during the past three years, afford data for estimating with a fair degree of accuracy the average climatic conditions of the Klondike. The average annual mean temperature is about 22° ; the mean of the three summer months is about 57° , July being 61° ; and of three winter months— 16° , with January— 23° . Spring may be said to open towards the end of April, the last zero temperature of the winter usually occurring about the 5th of this month. May, with an average temperature of 44° , is by no means an unpleasant month and the 23rd is the average date of the last frost of spring. Daily observations during five summers indicate that on the average the temperature rises to 70° or higher on 46 days and to 80° or higher on 14 days; 90° was recorded in Dawson in June, 1899, and 95° in July of the same year. These temperatures with much bright sunshine and an absence of frost during three months, together with the long days of a latitude within a few degrees of the Arctic Circle amply account for the success so far achieved by market gardeners near Dawson in growing a large variety of garden produce including lettuce, radish, cabbage, cauliflower and potatoes, and warrant the belief that the hardier cereals might possibly be a successful crop both in parts of Yukon Territory and in the far northern districts of the Mackenzie River basin. August 23 would appear to be the average date of the first autumnal frost, the temperature rapidly declining towards the close of this month. Although night frosts are not infrequent in

Average climatic conditions,

Average date of autumn frost.

Winter
temperatures.

September, the month as a whole is mild with a mean temperature of 42°. October may be fairly termed a winter month, the mean temperature being but 22.5 and the first zero of winter recorded on the average about the 18th. Ice usually begins to run in the Yukon about the second week but it is not until quite the end of the month or early in November that the river is frozen fast. The temperature on the average during a winter falls to 20° below zero or lower on 72 days, to 40° below or lower on 21 days, to 50° below or lower on 7 days, and to 60° below or lower on 2 days. In January, 1896, 65° below was registered at Fort Constantine, and in January, 1901, 68° below was recorded at Dawson.

Observations of rain and snow have until the close of last summer been very fragmentary but it is probable that the summer rainfall near Dawson is usually between seven and nine inches, and that the total snowfall of the autumn and winter is between 50 and 60 inches.

Dawson well
protected
from winds.

Dawson being situated near the river with high hills or mountains on all sides is well protected from the winds, and a feature of the town and indeed of the neighbouring country is the long periods of calm weather which occur.

GEOLOGY OF THE WEST COAST OF VANCOUVER ISLAND.

Mr. Arthur Webster.

Field of
operation.

In accordance with instructions received from Dr. Bell in June, 1902, to make a preliminary geological examination of the west coast of Vancouver Island, I beg to submit the following report of the work accomplished:—

Much difficulty was found in obtaining reliable information as to the best means of making the exploration. It was decided to employ Indians and their canoes, engaged from time to time from their numerous villages along the coast. This plan, after trial, was found to be impracticable, as only the old and useless men were left, the younger ones being away either sealing or fishing salmon for the Fraser river or other canneries. The few Indians remaining in the villages demanded exorbitant wages, and in any case were not to be relied on to work, except when hungry. I, therefore, considered it best to purchase a nineteen-foot sealing boat in Victoria and to do what was possible in it with Professor Haycock and one man. I may here say that I found the professor an able assistant, not only in regard to geological matters but for his skill in seamanship and willingness to help in every way.

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The trend of the westerly coast of Vancouver Island is north-westerly from Esquimalt harbour to Cape Scott. The shore is generally rocky, with a heavy surf usually breaking upon it, making it difficult and often dangerous to land on the exposed parts, but it is indented by many deep bays, arms and fiords, which, when once gained, afford excellent shelter. Much of the interior of the island has not, as far as I can learn, been explored, even by the Indians, who seem to live entirely near the salt water and seldom venture inland.

Viewed from the shore line the interior of the island appears to be very much broken by deep valleys and steep ragged hills, many of the latter being snow-capped. The highest of these hills, however, does not exceed, I think, six thousand feet above the level of the sea. The direction of the ranges and valleys is usually roughly parallel to the shore line.

The coast, including the inlets and bays, was examined only along the shore line, no inland work of any extent having been done, the thickness of the undergrowth, consisting of 'sallal' bushes and ferns, as well as the quantity of fallen timber, causing much labour and loss of time for very little result. Where examined the shore line was carefully worked out and will not, I think, require further investigation, but the work as a whole must be considered as only preliminary and the knowledge gained as but a foundation for future exploration.

Examination
confined to
shore line.

In describing the geology I shall use the late Dr. G. M. Dawson's nomenclature as far as possible, which is described on pages 10 to 14 of his report for 1887. In this description the igneous dark-coloured trappean rocks with associated mica-schists, and gneisses, are said to be interbedded with argillites and crystalline limestones, classed as Triassic, on the evidence of the fossils discovered in the argillites, and named the Vancouver series. On the west coast of Vancouver island, however, we find the igneous rocks piercing and including fragments and masses of the crystalline limestones, just as the granites at and near their contact with the traps pierce and include the latter. Nowhere did I see clear evidence of the limestones being interbedded with the traps, though in many places at first view there is every appearance of their being so. I therefore look upon the limestones as being older and unconformable. Owing probably to the highly altered and crystalline character of the limestones, only a few very obscure fossils were found in them—not, I fear, sufficient to determine their age, but perhaps by more extensive research, enough might be discovered to throw light upon this point. The tracing of the boundaries of these various limestone bands is, I think, of importance, as almost invariably the deposits of iron and copper ores are found at or near the contact of the limestones with the igneous or volcanic rocks.

Vancouver
series.

Admiralty
charts used.

In making the examination of the coast, the excellent charts issued under the direction of the Admiralty and the maps of the southern part of the island, procured from the provincial government, were used as a topographical base, rendering it unnecessary to make any surveys. The dips and strikes of the rocks and the bearings of the glacial striæ are given from the magnetic north, the variation being 23° east. The distances are stated in nautical miles.

Pedder bay
and inlet.

The party left Victoria on June 20 for Pedder inlet, where work was commenced, the country between the two points having been already reported on by the late Drs. Selwyn and G. M. Dawson. Pedder bay and inlet are situated about nine miles south-west of Victoria city and the peninsula separating them from Becher bay to the westward forms the extreme south-eastern point of Vancouver Island, Race Rock lighthouse being on a rocky island a mile and a half to the southward.

From Parker bay, about three-quarters of a mile eastward of the Quarantine station at Williams head, round Quarantine cove to Pedder bay, including the point to Williams Head lighthouse and the east shore of Pedder bay and inlet to its head, the exposures of rock are nearly continuous and consist of dark-coloured hornblendic masses very compact and hard but generally much shattered with no evidence whatever of bedding. At Ashe point, near the head of the inlet, they become slightly schistose and at Reid's farm, half a mile further west, decidedly so. The lines of cleavage strike N. 65° W., mag. On Mount Mary, a hill 350 feet high, lying about one mile eastward from Farm point, the hornblendic traps are less shattered and show small veins of epidote. A small talus is seen on the south-westerly side of this hill, showing the direction of the glacial movement.

Large granite
area.

From the head of Pedder inlet southerly, along the east shore as far as Shell point, these same rocks are met with, but they are much more shattered and are broken by numerous greenstone dykes. A large mass of granite and syenite occupies the higher ground and low hills of the peninsula between Pedder inlet and Becher bay. Just north of Shell point the granitoid rocks reach the shore and continue exposed from this point round Cape Calver to a quarter of a mile west of Argyle's farm, which lies on the main shore north-west of the westerly point of Bentick island. The eastern limits of this granitoid mass were not determined, but it appears to occupy the greater part of the interior of the peninsula, including North peak, Amy hill and Grouse hill. The greater portion of it is syenite, but it merges into diorite by imperceptible degrees. Bentick island and the smaller islands between it and the mainland are composed of the same rock.

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At one-eighth of a mile west of Argyle's farm, we again come upon the fine-grained hornblendic rock of the Vancouver series. The actual contact of this with the syenite is not seen, the exposures being about fifty yards apart and the interval covered by drift. From this point westward all round Beecher bay, the dark hornblendic rocks occupy the shore, varying somewhat, however, in that the crystals of hornblende are much larger about Aldridge point and at the 'Clallams' village in Campbells bay. Some prospecting for copper has been carried on along the shores of the bay but it has apparently been abandoned. Prospecting done.

All the islands in the bay are formed of the more or less massive hornblendic rocks of the same series. On Fraser island, the measures are very fine-grained and almost black. Exposures of the same dark hornblendic rock are seen all the way round from Murder bay to the north-east corner of Beecher bay and easterly to the head of Pedder inlet.

From Cape Aldrich westward and northward, round Beechey head to the entrance of Sooke harbour at East Sooke post office, the rocks are of the same (Vancouver) series, showing no evidence of stratification. Two old abandoned openings are to be seen a short distance inland from Company point. Little work had been done, however. These prospects are in magnetic iron ore, of which there may be a considerable body, but the ore is much charged upon the surface with iron and copper pyrites, with some pyrrhotite. Cape Aldrich to Sooke harbour.

Sooke harbour is entered by a narrow crooked channel, owing to a sand spit nearly closing its mouth, and might be easily passed by one not knowing the coast. In bad weather from the west, a heavy sea breaks at the mouth, especially if tide and wind meet. Once the harbour is gained, however, there is a large expanse of deep water and good shelter.

From West Sooke post office, following the northerly shore of the harbour eastward, no rock exposures are seen till we reach Coopers cove, towards the north-east side of the harbour. Here upon a narrow peninsula running eastward nearly across the mouth of the cove, occurs a cemented conglomerate, composed chiefly of beach pebbles and coarse sand holding small disconnected beds or patches of lignite. Inside the cove and at its north end dark green fine-grained hornblendic rock very compact and without any sign of stratification is seen.

On section 63 on the east side of Coopers cove there is a band eight feet wide of highly altered, somewhat shaly, argillaceous rock, interbedded with the harder and more compact greenstone, the contact on both sides being plainly visible. This band strikes N. 60° E., mag. and dips to the westward at an angle of 60°. On section 60 of Coopers cove.

Coopers cove, the same argillites are seen, having a thickness of 15 feet and dipping also to the westward, being separated from the former by 500 feet of dark green igneous rock, which weathers on the surface to rounded masses, like concretions. On section 57 on the east side of the mouth of Coopers cove, another exposure of the stratified rocks occurs, with the same dip and strike as before and separated by the dark green hornblendic rock in the same manner as the others. In the last two exposures the argillites appear to gradually merge into the dark green massive rock, no clear line of demarcation being seen.

Argillites.

From this point the stratified argillites appear in several places as far as the mouth of the small brook on sections 59-70, separated by and interstratified with the trappean rocks. The latter however, here, show a decided basaltic character.

Basalt.

From this locality southward, round the head of Sooke harbour to section 110, greenstones, some of which are of a basaltic character, line the shore. At the mouth of a brook in the south-east corner of Sooke harbour, gray basaltic rocks are met with, cut by numerous porphyry dykes and holding small veins with stringers of epidote. From this locality to section 98, including Anderson cove, only the dark massive igneous rocks are met with, showing little or no variation in character. These igneous rocks of the Vancouver series are seen westward along the south shore of the harbour as far as East Sooke post office. At Cartwrights, on section 97, traces of native copper are found in the hornblendic rock, adjoining a porphyritic dyke. These dark rocks extend southward across the post road, running between Victoria and East Sooke post office.

Mount
Maguin.

Mount Maguin, lying to the south of sections 98-110, occupies a considerable area and is composed of syenite or diorite. At and near the junction of the syenite and igneous rocks there is what appears to be an extensive deposit of copper ore, chiefly chalcopyrite but mixed with some magnetic iron. A shaft, thirty feet deep, had been sunk and work was still going on with a small force of men on the 1st of July. The ore occurs in a hornblendic gangue and is said to assay well. The prospect is well situated for shipping, having a fair grade to deep water. The work was not sufficiently advanced to form any reliable estimate of the extent of the deposit. About 150 feet north of the copper deposit, a peculiar granitoid rock appears, consisting of large crystals of light-coloured, almost white feldspar, and dark grayish green hornblende. This outcrop is of small extent and could be traced for only a few hundred feet.

Cape
Sherringham.

At Cape Sherringham and for a mile to the eastward towards the mouth of Sooke harbour, the rocks consist of hard massive greenstone,

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holding epidote in veins and patches. In the breaks between the exposures of trap there occurs a sandy conglomerate, holding angular and rounded fragments of the same greenstone. Some of the embedded masses show striae; but the glacial action may have been prior to the conglomerate formation, the trap itself showing glacial striae striking S. 75° W. At the mouth of Coal creek, one mile and a half east of Sherringham point, large exposures of sandstone are seen, holding vast quantities of fossil shells of various species of which a sufficient collection was made to enable the horizon of these beds to be defined. These sandstones lie nearly flat, dipping at a small angle to the westward. The sandstones are seen resting on the trap just eastward of Sherringham point. An ascending section gives the following:—

	Feet.
Moderately hard gray sandstone.	10
Sandstone shell beds with traces of lignite....	6
Soft sandstone with concretions.....	12
Friable sandstone.....	10
Loose earth and loam	8
	<hr/> 46

A portion of the lower bed is covered by the sea, so that its thickness was not determined.

From half a mile west of Muir creek to the mouth of Coal creek there are extensive exposures of these sandstones, more or less fossiliferous and holding lignite, the actual contact with the traps not, however, being seen. The traps are partially basaltic.

At Otter point basaltic greenstones also occur.

Along the north-east shore of Sooke bay, half a mile from the entrance to Sooke harbour, banks, 60 to 70 feet high are seen, consisting of boulder clay, holding striated pebbles and boulders, and underlaid by coarse conglomerate. A few remains of vegetable matter are seen in the clays. On section 16, Sooke bay, the following descending section of these clays and sandstones occurs:—

	Feet.
Boulder clay.....	15
Soft sandstones and gravel with concretions of sandstones.....	20
Friable sandstones.....	14
Sand and small pebbles loosely cemented....	12
Conglomerate.....	2
	<hr/> 63

Section on
Sooke bay.

The thickness of the lower bed of conglomerate was not determined. The conglomerate is partly cemented by oxide of iron.

The following ascending section of these sandstones occurs on section 6, Sooke bay :—

	Feet.
Beach at high water.	
Hard bedded sandstones, beds 6 inches thick.	4
Conglomerates (beach pebbles)	6
Soft friable sandstone	10
Boulder clay	20
	<hr/>
	40

A section given by a bore-hole put down on the west side of the sand strip at the mouth of Sooke harbour, by Dr. C. Forbes in 1863, is stated to be as follows in descending order :—

Section on
bore-hole.

	Feet.	Inches.
Drift	?	
Clay and sand	?	
Conglomerate	4	0
Red sandstone	12	0
Gray sandstone	15	0
Till (shale) ?	8	0
Coal	0	6
Shale	2	6
Fire clay	2	6
Till	6	0
Kringle	1	0
Red sandstone	3	0
Coal	1	0
Shale and fire clay	18	0
Gray sandstone	2	0
Kringle	1	0
Till	6	0
	<hr/>	<hr/>
	82	6

Sherringham
cape to Provi-
dence cove.

From Sherringham point to Providence cove, the measures were not examined, the distance along the coast being 22 miles, but only seen from the steamer 'Queen City' on its way to St. Juan port. After leaving Sherringham point, they appear to consist of a dark coloured mica schist of the same character as those at Providence cove. The eastern boundary of these schists was not determined, but is probably at or near the mouth of Jordan river.

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Providence cove lies about three miles east of Cape St. Juan, which forms the south-east point of Port St. Juan. The rocks here consist of mica schists of rather coarse texture than those to the westward. They are so folded and twisted that it is impossible to distinguish bedding from cleavage, but the general strike appears to be from N. 10° E. to N. 60° E., with a westerly dip at an angle of from 10° to 40°. At several points beginning about one mile west of Providence cove and extending to Minnesota point, which is about one-third of a mile east of Cape St. Juan these slates or schists are overlaid unconformably by conglomerates and friable sandstones, notably at Minnesota point, where they have a thickness of forty feet. These sandstones resemble those of Coal and Muir creeks, and the lower beds contain a few obscure fossils, chiefly corals.

At Cape St. Juan and on Observatory island, just off it, the slates and schists are well seen, but so broken, twisted and altered by intrusive trap dykes, (some of which run with the strike, having offshoots cutting the slates at right angles) that no estimate of the thickness could be satisfactorily made. The general strike of the slate beds is north-east and south-west, with a westerly dip of from 10° to 45°. Both sides of Port St. Juan are formed by mica-slates or schists, very Port St. Juan. much broken and contorted by trap dykes which cut them in all directions. The shores on the west side rise abruptly from the water's edge and are worn into many curious forms from the erosion of the heavy surf which continually beats upon them. The valley of the St. Juan river falls in from the eastward, forming a low delta which extends some distance inland. An island of considerable extent lies at its mouth, nearly closing the southern passage by a sand bar, the main channel flowing into the harbour on its north side.

The slates and schists of the St. Juan, extend up the Gordon river, Gordon river. which joins the former about half a mile from its mouth. For some two and a half miles they are much bent and twisted by numerous trap dykes. The strike is from north and south to south sixty degrees west, the dip being to the westward at all angles from 10° to 90°. These are followed to the northward by a dark greenish diorite which shows itself for nearly half a mile. About a mile from Newton's camp, or some five miles on the trail from the mouth of the Gordon river, a band of highly crystalline limestone occurs, forty feet in thickness, followed by diorite, the northern boundary of which was not determined. Mount Edinburgh, lying N. 15° E. mag. from Newton's camp, is said to be of limestone.

The Newton mine, which is on the Gordon river about six miles Newton mine. from its mouth, is in magnetic iron ore with a good surface showing, but it has some traces of iron pyrites. A good deal of work has been

done here. A shaft nearly 300 feet deep has been sunk, and at this depth it is proposed to drive a cross-cut to tap the ore. About 14 hands are employed, but as yet, no ore has been shipped. The timber along the Gordon river is generally good and consists chiefly of spruce, hemlock and balsam. One spruce tree 5 feet 2 inches in diameter at twenty feet from the ground had 285 well marked rings of growth.

Owen point to Cape Beale. At Owen point, on the north-west side of Port St. Juan, the mica schists are seen overlaid unconformably by sandstones similar to those seen between Providence cove and Minnesota point. The sandstones lie nearly flat and continue for some miles towards Carmanah.

Owing to bad weather and westerly winds, a stretch of about thirty miles of coast between Owen point and Cape Beale could not be examined, but it is probably occupied as far as Nitinat by the St Juan mica-schists of the Vancouver series.

In the bay upon the main shore, 200 yards west of the head of Bamfield creek, fine-grained, dark trappean rocks are exposed, having a slight conchoidal fracture, cut by masses of intrusive syenite and gray diorite containing a very small proportion of biotite. The greater part of the diorite has a grayish appearance, but one band is of a reddish colour. The ridges run about N. 75° W. mag.

The islands to the westward of this bay were not examined, but they seem to be formed of similar rocks. From this bay to the south and eastward, towards Cape Beale, as far as Sandy bay, only fine-grained traps were seen and they are not cut by any intrusive dykes. Upon the trail towards Cape Beale and about one mile and a half south from the head of Bamfield creek occurs a band of fine-grained gray diorite which is seen as far as the Long beach, and here the diorite cuts the traps of the Vancouver series. On Long beach black magnetic sand is found exposed in beds of one-sixth to one-half inch thick on the lee side of a mass of rock. No colours of gold were observed and the deposit is of no importance. Diorite, both of light and darker coloured varieties, extends from this point to Cape Beale.

At Cape Beale lighthouse, which stands 130 feet above sea-level, upon an island separated from the mainland by a narrow channel which is almost dry at low tide, the rock is of coarser grain and lighter colour, much resembling a granite. There is no evidence of glacial action.

Cape Beale
lighthouse.

The exposures on Bamfield creek consist of fine-grained hornblende trap-rock like that cut by the diorites to the south of it. From the mouth of Bamfield creek north-eastward up the easterly shore of the Alberni canal to Dixons island and point only grayish

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diorites are met with. Here a fine-grained crystalline limestone shows itself, striking south 50° to 60° E. and dipping south-westerly at an angle of 50° . The stratification is very apparent, the beds being from 5 to 7 inches thick and the band probably 200 feet thick.

The south-west point of Poett cove is of fine-grained greenish trap. About a hundred yards further into the cove there is crystalline limestone, apparently interbedded with the trap-rock, striking north and south and dipping westerly at an angle of 40° to 50° .

Limestone also occupies the north-east side of the entrance of this cove, striking S. 20° W., dipping westerly at an angle of 35° and seen for half a mile into Numukamis bay, succeeded by light-coloured dioritic beds. Crystalline limestone is again seen on the south-east end of Santa Maria island and on a small island just off it, while on the north end gray granitic rock is met with. At the south end there are traces of magnetic iron ore in what would seem to be a dyke which breaks up and shatters the adjoining rocks. Limestones.

The Sarita river falls into the Alberni canal from the eastward, about half-way up Numukamis bay, forming a flat at its mouth about three-quarters of a mile wide, its valley being bordered by low hills on either side. An iron deposit, associated with limestone, occurs a few miles from its mouth. On a small island opposite the mouth of this river, a porphyritic rock is seen, which is probably intrusive. At the point on the north-eastern shore, near the small Indian village, is a much jointed and broken greenstone, resembling that seen on the south end of Santa Maria island. A highly altered chert-rock occurs in the small bay about one mile north-east of the mouth of Sarita river. These rocks are also seen on Congress island, rather less altered and having an obscure bedding. The stratification would appear to be horizontal, but it is much disturbed by trap dykes. Sarita river.

Fine-grained greenstone forms the point of land separating Numukamis from San Mateo bay, but at Cherry point on the north-east side of the bay, granitoid rock appears for about half a mile. Diorites or granites are seen alternately from this point, as far as Coleman creek, the granitoid rock being rather in excess of the trap. From Coleman creek northward to opposite the mouth of Nahmint river rocks of the same character occur, except that perhaps greenstone predominates. San Mateo bay.

From this point to within half a mile south of the mouth of China creek, exposures of a grayish granite are almost continuous. From the shapes and slopes of the hills in the interior, I would judge them to be also granite. From China creek northward through the second narrows to the head of the canal at Stamp harbour, the rock is all Hills in the interior probably granite.

dark greenish trap of the Vancouver series, as is also the west side of the canal from its head to opposite Mount Hankin where an obscure strike was observed south 5° east; dip westerly at an angle of 25°.

From half a mile south of Coos creek, where a small stream comes in from the westward, grayish granite, composed of hornblende and feldspar with but little free quartz, is exposed almost the entire way to the north side of the mouth of Nahuint river. Thence as far as the ore bunkers of the Monitor mine, about half a mile north of the mouth of Green creek, greenish fine-grained trap is almost continuous.

Uchucklesit
harbour.

From Green creek along the north shore of Uchucklesit harbour, bands of crystalline limestone and fine-grained trap, which at first sight would appear to be interbedded, are met with: but in a small bay two-thirds of a mile to the south-west of the Monitor bunkers, the hornblendic rocks are certainly intrusive, cutting and including fragments and masses of the limestones. The limestone on the small island, at the mouth of Uchucklesit harbour, strikes N. 50° E.; dip easterly at an angle of 25° to 45°.

The limestones are as much altered in the middle of the bands as at the contact with the traps and are so folded and contorted that a very close survey would be required to make even an approximate section.

Copper.

At the Happy John claim, a copper prospect adjoining to the westward the Monitor mine, the contact shows without question that here the limestone is the older rock, the trap inclosing fragments and masses of the limestone.

The west side of Uchucklesit harbour, the south-westerly point and the shores of Rainy bay and Useless inlet are of hard compact hornblendic rock, marked by epidote in small veins and stringers. At the south-east point of the entrance of Rainy bay, a small band of amygdaloid is met with. Owing to heavy weather we were unable to get out of the south-west entrance of Useless inlet and were obliged to return round the north end of Seddall island to the small harbour of Ecole on its south-east side and opposite the north end of Copper island, where we remained a day to dry out provisions and blankets.

Ecoleharbour.

The rock on the north side of Ecole harbour and extending for a mile or more to the westward, is white crystalline limestone, much cut by traps, confirming the view that the limestone is the older rock and that the traps are intrusive, at least in certain localities. Mr. Haycock found here traces of obscure fossil remains. The rock on the easterly side of Seddall island is all dark, fine-grained trap.

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On the north-east end of Copper island and down the east shore as Copper island, far as Clifton bay, crystalline limestones, intimately associated with traps, strike south 40° west. These limestones cross the middle of Copper island and can be traced as far as Marble cove on its westerly side. On Copper island, a short distance inland and seven hundred feet above sea-level, the Pacific Steel company of Ironside, Wash., U.S.A., are opening up an iron claim. The ore is magnetic iron of good quality and said to assay 60 per cent metallic iron. A tunnel has been driven two hundred and two feet following the ore, which shows a width of about one hundred feet near the limestone and trap contact and extends to the top of the hill, one hundred feet above the sea. The mine has good facilities for shipping, as there are sixty fathoms of water in the cove.

Limestone is reported to occur a short distance up the Sarita river, at another iron property belonging to this company. The small islands between Copper island and the eastern main shore are of fine-grained dense hornblendic rock. So far as observed, the limestone, when in large bands invariably rests on the trap of the Vancouver series.

The shores between Useless inlet and Clayoquot were not examined, owing to bad weather and a desire to take the steamer to the latter point. White crystalline limestone is said to have been quarried for marble in Ettingham inlet. Useless inlet
and Clayoquot
sound.

Clayoquot store and post office are situated on a small island in Broken channel, lying about half-way between Vargas and Meares islands. The formation here is a very fine-grained dark hornblendic rock, having the general appearance of a trap, but in places showing obscure bedding.

The southern part of Round island, lying a mile east of Clayoquot post office, consists of gray granite, the north half being of a very dark fine-grained hornblendic rock, weathering almost black. Being cut by dykes, the actual contact of these rocks with the granites is not evident, but the line of general contact strikes about $N. 70^{\circ} W.$ The same dark-coloured hornblendic rock is seen on the main land at the low point east of Round island. These rocks are again seen on a small island at the entrance to Brownings passage. Here they show a slight slaty cleavage and are exposed as far as the narrows in Brownings passage, where on a small island, gray micaceous hornblendic granite is met with. Round island.

At the east end of Meares island, granites occur in large masses Meares island. along Indian island, they appear to be more hornblendic, carry less mica and are of a darker colour. Here mica-slates striking from N.

40° to 60° W., dip easterly, at an angle of 85°, much resemble gneisses and contain a good deal of free quartz, running parallel to the bedding and cleavage. Many of the layers weather to a whitish or a drab colour. The fracture is dark gray with dark-coloured mica on the cleavage faces. The thickness of these slates is probably about 1,600 feet.

Indian island. The easterly end of Indian island and the point of the mainland opposite consists of dark gray granite, extending for some distance inland. Crossing eastward to the mainland, these granites continue for a mile into the bay, bearing N. 8° E. from the east end of Indian island, and are followed by gneissic rocks, striking N. 70° W., to within a mile of the mouth of Kennedy river, where dark hornblende granite occurs and extends half a mile up the river, when white crystalline limestone shows itself as far as the head of the rapid. From the rapids, up the river to the lake, the shores are low and swampy, showing no exposures of rock. A small salmon cannery is in operation at the mouth of the river.

Kennedy lake. Kennedy lake, of which this river is the outlet, is a considerable sheet of fresh water lying to the north of Wreck bay and east of Tofino inlet and separated on the south from the ocean by several miles of low-lying sands. The surrounding country is covered by a scrubby growth, chiefly of spruce, and the lake is fed by the Elk river, which falls into its north-east arm. Going round the shores dark-weathering, very hard, hornblendic rock and white crystalline limestone are seen at the point north of a deep bay on the south side of the lake. This has beds or rather bands of a darker coloured hard character which are not so much affected by weathering as the softer ones. The strike is north 45° west; dip south-westerly at an angle of 50°. I was not able to determine its thickness.

Limestone. Hornblendic rock, cut by several trap dykes succeeds the limestones. At the extremity of the point of South bay is a fine-grained amygdaloid marked by epidote. Greenish-gray hornblendic rocks occupy the south-east side of South bay as far as a small stream from the south. Crystalline limestones, cut by greenstone dykes, compose the south-east shore as far as the south side of a small bay, bearing S. 10° E. mag. from Long island. Another exposure of limestone, striking S. 20° E. and cut by an 8-foot dyke, is seen in a small bay east from the south end of Long island.

Elk river. North-eastward of Long island, Long point runs out to the north-westward. This consists of a dark-greenish fine-grained trap, very compact and holding feldspar and epidote. Rocky island, half a mile north-west of the point, is composed of the same kind of rock, as

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is also the western side of the north-east arm, as far as the mouth of a small stream falling in from the north. The rock on both sides of the narrows towards the mouth of Elk river is light-coloured hornblende granite, holding free quartz. This is followed northward by greenish trap, holding epidote, of the same character as that on Long point. A small exposure of limestone is seen at the mouth of Elk river. The river is not shown correctly on the chart.

Mount Maitland, to the eastward, appears through the glass to be Elk river, capped by limestone. Several prospects lie some few miles up Elk river, one, the 'Rose Marie,' having free gold in quartz. From the narrows, southward along the west side of the point, towards the outlet a massive fine-grained hornblende rock prevails for three-fourths of a mile. Then a small exposure of crystalline limestone is seen resting on this rock. The east shore of the western arm of the lake, Agnes island and the point south of it, consist of a coarse-grained hornblende granite. The rock seen on both sides of the narrows is a dark-weathering whitish-gray granite, followed towards the head of the arm, by a dark greenish coloured trappean rock which weathers much like a granite. Half a mile from the head of the inlet, which is wrongly shown on the map, there is a small exposure of crystalline limestone, striking S. 20° E. and dipping easterly at an angle of 40°, cut by intrusive greenish trap. The point on the west side of the entrance to this arm is composed of a greenish hornblende rock, probably diorite. At the cannery on the right bank of Kennedy river a knob of gray granite is met with.

On the long point jutting out from the mouth of Kennedy river, forming the south-eastern entrance to Tofino inlet, there occurs a gneissic rock, which strikes S. 80° E. and dips easterly at an angle of 35°. The east shore of Tofino inlet, with the exception of a small exposure of crystalline limestone, is gray, coarse-grained granite. The limestone occurs again about one mile south from Deer river. At one-eighth of a mile from the mouth of Deer river, a gray schistose rock replaces the granite. The beds here would appear to be a highly altered and contorted sedimentary rock. Greenish fine-grained trap is seen at the mouth of Deer river. On the west shore, for two miles south from the head the Vancouver series is represented by igneous hornblende rock, after which gray schistose measures are met with, consisting of rather coarse-grained gneissic rock containing quartz, feldspar, mica and hornblende.

A very small patch of white crystalline limestone, associated with greenish igneous rock, is seen on a small island just north of Woman island. Coarse gray granites and granitoid rocks form the long point stretching southward between Tranquil creek and Tofino inlet.

Tranquil
creek.

Limestone occurs on the west shore at the mouth of Tranquil creek, having a width of 150 yards, and striking from S. 60° W. to east and west. Gray granite lies on both sides of it. From this locality southerly to the main point north of Warne island, nothing but coarse gray granite is seen.

The north end of Warne island is granitoid rock, consisting of veins of true granite with quartzite and dark hornblendic zones. Mica-schists or micaceous gneiss, striking N. 20° W. and dipping at an angle of 60° occur at the most southerly part of the point, turning into Deception passage; probably a continuation of those seen on Indian island. Close to the entrance of Fortune channel, dark hornblendic rock, slightly schistose in places but chiefly massive, is seen and gray granites occupy the west shore from the entrance to a point opposite Race narrows.

Warne bay.

Compact trap, marked by epidotic nodules and gashes occupies both sides and the head of Warne bay. The face of the most southern part of the north shore in Race narrows is white crystalline limestone, with a marble-like fracture, weathering to an ochreous yellow. Towards the western point, the limestones assume a schistose character and strike N. 40° to 50° W.: dip. N.E. at an angle of 30°. These are succeeded at the point leading into Bedwell sound by greenish trap.

Bedwell
sound.

Leaving the limestone, which is much twisted and contorted by intruding trap on the east shore, opposite Fern point, nothing is seen in Bedwell sound but the igneous rocks of the Vancouver series which occur at one point on the west shore about half way to the head of the sound; then a small band of cherty bedded rock is seen for 400 yards, striking north 30° west and dipping westerly at an angle of 20° to 40°. The sound has high rocky banks, alternating with short beaches.

Cypress bay.

From Turn point, running to the southward between Bedwell sound and Cypress bay, high rocky and bare bluffs show themselves. They are composed of dark and rather compact trap. Just round the point and opposite some small islands in Cypress bay, a bedded cherty rock appears, resembling that seen in Bedwell sound. This continues round Cypress bay to Calm creek. From this creek to Trout river, which falls into Cypress bay the ordinary traps are met with. The point on the left bank of Trout river at its mouth, is a dark diorite, very compact and weathering to a spotted white and green surface. With the exception of a small vein of calcareous rock, associated with traces of yellow copper ore, seen in a small bay south of the mouth of Trout river, nothing but the trap was noticed around the Cat-faced mountains as far as Bawden bay, near the entrance of Herbert arm. These rocks continue round Charles point, at the en-

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trance to Herbert arm, occasionally becoming schistose and all of them being marked by epidote in stringers and nodules. Three-quarters of a mile east of Charles Point, towards White pine cove there is a dark-weathering crystalline limestone, having harder and somewhat siliceous bands. The strike is S. 40° E.; dip very irregular but generally to the south-westward at angles of from 30° to 60°.

The islands north of this exposure show bands of cherty white limestone, highly crystalline and apparently interbedded with the trap. From these islands the rock around White Pine cove is green, heavy trap, much marked by epidote. Just beyond the north point of the cove, yellow-weathering limestone is seen, in a narrow band, having trap on either side. Its strike is S. 10° W.; dip easterly at an angle of 50°. This band follows the shore for several hundred yards and is somewhat slaty in structure. It is followed to the north by green hornblendic rocks to within a mile of the head of the arm, when a small exposure of crystalline limestone is seen, striking N. 20° E.; dip eastward at an angle of 45°. The head of the arm is bounded northerly and easterly by high rocky mountains with steep sides and pointed, jagged crests. Small exposures of limestone occur at several points along the west shore, intimately associated with fine-grained dark trap. On the southern part of a long point, there is a bed of trappean agglomerate in which the surfaces of the balls or nodules are apparently fused together at their contact with one another. This bed stands out of the water about ten feet and is overlaid and flanked on either side by massive trap. The exposure is about fifty feet wide. Across the bay south of this point there is a small exposure of crystalline limestone, striking S. 20° W. and dipping westerly. This seems to underlie stratified gneissic rock with the same dip and strike for a short distance. Then maintaining the same dip and strike it is found for a short distance overlying rocks of the same character.

White Pine
cove.

Limestones.

From this locality going round into North arm to a point half a mile south of the Indian village of 'Alelyon,' nothing is seen but massive hornblendic rock. Here a stratified quartzite, weathering brownish-yellow and holding quantities of small cubes of iron pyrites is seen striking N. 70° E., with a northerly dip of 50°. From the village, dark gray hornblendic granite extends to one mile south of the eastern entrance to Shelter arm, here on a small island a thirty-foot band of crystalline limestone appears, striking east and west. The contact of clearly intrusive granitoid rocks is seen on both sides of it. From this, for half a mile into the narrows, on the east side of Obstruction island, occurs coarse-grained trap, having a slight tendency to become schistose.

Shelter arm.

Glaciated
cliffs.

The northern point of the narrows consists of a massive granite, the small island just off this point being also granite of a gray colour, holding much free quartz. These granites extend round the point, where the contact with the dark green trap is plainly seen, the granites being certainly the newer and intrusive rock, forming small dykes which enter the trap and inclose many fragments of the latter, their edges being sharp and distinct. The green trap extends round the bay to the narrows at the head of the arm. This is slightly schistose in spots, but more massive at a distance from the granite. Granite and granitoid rock form both sides of the arm at its head, rising in high precipitous cliffs, especially on the west side. The hills appear to be glaciated for at least 2,000 feet in altitude.

On the north-west shore of Shelter arm from the narrows as far as the stream and beach, north of Obstruction island, with the exception of a small patch of crystalline limestone, the rocks consist of diorites cut by intrusive granites, inclosing masses of the older rock. From this stream to a deep bay, north of the long point running eastward towards Obstruction island, nothing is met with but dark green fine-grained greenstone, holding less epidote than usual. At the point itself and along the shore thence westerly and along both sides of Sydney inlet to within three and a half miles of Sharp point and Refuge cove (at the south-west entrance to the inlet), only granitoid rocks are seen. They often resemble gray diorite and hold a small percentage of mica.

Flores island.

On the north-east and north-west sides of Flores island, including Steamer cove and Rocky passage, south to within two and one-half miles from the mouth of Matilda creek, gray fine-grained granites are met with. Thence southward, including Matilda creek and the shore past Ahousat village, on to White Sand bay, only greenstones of the Vancouver series are exposed.

Cone island.

Cone island lies in the middle of the North Arm channel, about two and a half miles west of north from Ahousat village. The hill predominating this island is in the form of a nearly perfect cone formed of granite and rising about 1,000 feet above the sea. On the south-west side of the island, half a mile north from the south-west point, gneissic rocks of no great extent are found striking east and west and dipping northerly at an angle of 45°. The north-west corner of the island is formed of a fine-grained gray hornblende granite.

Coal measures, with some coal in sight, are said to occur at Rafael point on the south-west corner of Flores island. We were unable, however, to make an examination of that part of the island.

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Friendly cove in Nootka sound was reached by the steamer *Queen* Nootka sound. *City* on August 23. From Burdwood point, eastward from Friendly cove, gray granite extends for a mile to the north-eastward and as far southward as Escalante point, but it was traced no farther. These granites are succeeded to the eastward, between Mounts Banke and Adair, in the Zucarte channel, by trap, which, in spots, assumes a basaltic form. Granite, which appears to be intrusive, is seen for half a mile in the bay under Mills mountain. This is followed by dark trap rock, much broken, which, west of Mount Sergeant, becomes slightly schistose, and continues to within a short distance of Point Anderson, itself composed of granitoid rock cutting trap. On the north-east side of this point, a small band of calcareous character strikes N. 10° E. and dips westerly at an angle of 45°. This band is seen for a short distance along the west side of Camp bay.

The easterly side of Camp bay and eastward for half a mile is composed of greenish trap. Gray granite, holding hornblende and mica extends thence with but little interruption for about seven miles and a half up Muchalat arm. At a small brook, about eight miles east of Camp cove, where crystalline limestone occurs, cut and broken, in many places, by both granite and greenstone dykes, the strike of the limestone is S. 70° E; dip southerly at an angle of 45°. From this exposure of limestone to the cannery at the stream and beach south of a small island in mid-channel, granite and granitoid rock holding fragments of the Vancouver series were observed. From this point, gray granite and dark hornblendic rock alternate round the point of, and for half a mile into the southerly extension of the arm where a band of crystalline limestone about 250 yards in extent occurs. This band is not so highly crystalline as is usual with these limestones, but no traces of fossils were discovered. It strikes N. 60° W. and dips south-westward at an angle of 30°. It is probably the same band as that seen two miles west of the cannery. The westerly side of the southerly end of this arm consists of gray granite.

Along the east shore of this arm, from the head as far as the mouth of Gold river, rocks of the Vancouver series are seen continuously. They consist chiefly of fine-grained, dark greenstones, holding very small cubes of iron pyrites and a few small, scattered garnets with epidote. Opposite the point on the west shore of the main arm there occurs a small exposure of amygdaloid. At the mouth of Gold river there is a small Indian village of a few huts. Tradition says that the Spaniards, when occupying the fort and trading post at Friendly cove found gold in this river and worked the gravels. Trap extends from the point on the west side of the river for a quarter of a mile.

Gravels of Gold river said to have been worked for gold.

Gray granite with an occasional small exposure of trap forms the whole north shore of Muchalat arm to the point turning northward into Tlupana arm, including Gore island, which is all gray granite. The granites when in contact with the trap rocks inclose and surround fragments of trap so plentifully in places as to make it difficult to define the dividing line within several hundred feet. The fragments of trap inclosed vary in size from a few inches to several cubic feet, and their edges and angles are but little worn.

Tlupana inlet. The granitoid rocks continue along the east shore of Tlupana inlet and form the southerly part of Separation saddle. At the northerly narrows on the west side they appear in very abrupt bluffs, covered by moss and bearing a few scattered firs and spruces. On the north-west side very white fine-grained crystalline limestone is cut by many intrusive dykes of dark trappean rock. Its strike is S. 20° E; dip easterly at an angle of 40°. These limestones are seen as far as the stream and beach at the head of North-east bay. Following the north side of the bay, fine-grained dark hornblendic rocks are met with for a mile from the head of the bay to a point opposite a small island. Bands of white crystalline limestone are seen here, both on the main shore and on the islands. The band upon the main shore is seen for some 200 yards. The strike is very uncertain, varying apparently from N. 30° W. to east and west and the dip is northerly at all angles from 5° to 50°.

Limestones cut by trap dykes.

These limestones are followed for a mile south, on the west shore, by fine-grained hornblendic rock. Gray granite is seen on the west shore for a little over half a mile and is succeeded, opposite the south-west end of Separation saddle, by crystalline limestone, cut and broken and so thrown about by intrusions of greenstone that no dip or strike can be indicated. These limestones are seen for nearly a mile, or to the point turning south-west along Tlupana arm. From this point south-westerly and up half-way to the head of Deserted creek, gray granite and granitoid rocks are met with. Limestones are seen around the head of Deserted creek from this point to a place on the south-west shore, nearly two miles from its head. These limestones are much cut by trap dykes; the general strike is, however, south 80° west. They are succeeded by a gray granite, inclosing fragments of a darker rock (some of which appear to be partially flattened) to within a mile of the north-east entrance of Tahsis canal to the north of Canal island.

The north half of Bligh island and its eastern side, including the long peninsula between Ewin creek and the Zucearte channel is composed of the ordinary gray granite. The south-westerly half, including the islands lying between it and Nootka island, are of green hornblendic rocks of the Vancouver series, much cut by granitic dykes.

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From Friendly cove (Yuquot village), for two miles north, dark hornblendic rocks occur, which may be highly altered sediments, but having a bedding so very obscure that it cannot be distinguished with certainty. To the northward of these follow, on the west shore, gray granite and granitoid rocks, which include Narrow island at the mouth of Tahsis canal as far as two miles south of Tahsis narrows, which lead westerly to Hecate channel and Esperanza inlet.

On the eastern side of Tahsis canal as far as the north end of Narrow island, the measures are concealed, but they are probably the Vancouver series. From this locality northward for three miles, granite and granitoid rocks are seen. Thence to the head of the canal, a distance of about ten miles, rock of the Vancouver series is exposed, consisting chiefly of dark traps. A small exposure of limestone occurs half a mile beyond the second narrows on the east shore. Darks traps
of Vancouver
series.

This limestone is succeeded to the northward by an exposure of agglomerate, dark in colour and consisting of rounded masses of from one to six inches in diameter. This is followed by crystalline limestone, which is seen along the shore for two miles, striking S. 60° E. to S. 80° E. and rising in bluffs 200 feet high at 300 feet from the shore. These limestones are very much cut up and thrown about by the usual intrusive hornblendic rock, which is seen in several places completely surrounding fragments of limestone several feet in length. No fossils rewarded a diligent search. The limestones are followed by traps for half a mile. The latter are succeeded to the northward by crystalline limestone, as far as the beach, a mile from the head of the canal. Dark green hornblendic rock is seen on the east shore near the head of the bay.

On the west shore for a mile and a half, crystalline limestone again occurs, striking S. 60° S.-E., mag., and is probably a continuation of the band on the east shore. From the limestones southerly to Tahsis narrows, on both sides of the narrows, and for two miles south of them, rocks of the Vancouver series are seen, consisting of dark-coloured fine-grained trap. Tahsis
narrows.

On the north shore of Hecate channel and the eastern shore of Zeb-allos arm, as far as the northern end of the arm, the exposures show little variety, consisting of a fine-grained hornblendic rock, weathering occasionally to a reddish brown, which may without question be classed as belonging to the Vancouver series. No granite or limestone was seen on either shore till reaching the point on the west side of the entrance, when grey granite appears, holding at and near its junction with the traps, masses and fragments of the latter.

Esperanza
inlet.

From the entrance of Zeballos arm the north shore of Esperanza inlet, to within half a mile of the point of Espinosa arm, is occupied by gray granite. The eastern point of Espinosa arm and the east shore, as far as its northerly head, show nothing but the Vancouver series, and from the head southward on the west shore to within two miles from the entrance, the same rocks are seen. From this point to the entrance of the arm the rock is gray granite with darker masses embedded in it.

Port Eliza.

These gray granites extend round the point of Queens cove and up both shores of Port Eliza to within a mile of its head. Thence to the head, dark green, almost black, hornblendic rocks, holding much epidote, are seen on both sides. On the west side, three miles from the entrance of Port Eliza, a small exposure of hornblendic rock separates the granites.

The shores from Lending hill on the west shore of the mouth of Port Eliza to Point Tatchu on the open coast, six miles to the westward, are formed of the hornblendic rocks of the Vancouver series. These rocks include Catala island and all the small islands and reefs seen in the north channel and Rolling roads, together with Harbour island at the entrance of Port Eliza. On the extremity of Tatchu point, soft bedded sandstones occur, resembling those seen at Point St. Juan, except that no fossil remains were found in them. An ascending section based on the Vancouver series is as follows:—

	Ft.	In.
Fine conglomerate with small beach pebbles . . .	0	10
Fine-grained gray and reddish sandstone.	3	6
Coarse conglomerate of beach pebbles, 5" x 4" the largest, some pebbles but little worn; a few beds of fine-grained sandstone less than 4 inches thick.	19	6
Fine-grained yellowish-gray sandstone in beds of from 2 feet to 6 inches.	46	0
	<hr/> 69	<hr/> 10

Nootka sound
to Cape Scott.

On the way back to Victoria, a trip was taken by the steamer *Queen City*, from Nootka sound to Cape Scott, but unfortunately the weather both going and returning was so wet and foggy that little was learned of the shores; but much was ascertained as to the best means of carrying on farther explorations. Victoria was reached on October 2.

Glacial striae are seen in all the arms running inland and generally along the coast from Victoria to Point Tatchu. While the direction

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was noted in all cases, further examination inland towards the mountain ranges, from the heads of the arms and fiords, would be necessary to determine the thickness and extent of the ice cap or caps which no doubt covered the greater portion of Vancouver island. The present information, gained tends, I think, to show that north of Port St. Juan, all the arms extending inland from the sea held separate glaciers, as in all cases the course of the striæ is with the general trend of the arm in which they were observed.

In the Alberni canal, the evidence is that an extensive glacier reached for a long distance inland and had its discharge through the canal into Barclay sound; while the ice from the north of Kennedy lake found its way to sea-level across the lowlands between it and Wreck bay. Observations through the glass towards the mountains would make it appear that the glacial roundings and markings reach an altitude of at least 2,000 feet. The absence of terraces is probably owing to the steep and rocky character of the shores. Perched boulders were nowhere observed.

Glacial evidence in Alberni canal.

The mines on the west coast of Vancouver island seem at present to be suffering from a general depression. The copper mine at Yuka in Quatsino sound is, I believe, the only one shipping ore in any quantity, while there are several properties that might be made productive.

There are several iron claims, in which capital would be, I think, well invested. The copper ores, chiefly chalcopyrite, appear to lie mainly in pockets and are difficult to follow and trace. Nowhere on the coast have I yet seen a true vein carrying ore of permanent value, but it is a country well worthy of being thoroughly prospected.

Iron and copper.

Very little land on the west side of the island is available for agricultural settlements. Between Victoria and Sooke, there are numerous farms, but the land is usually very light and gravelly, requiring much manure to produce a crop of grain; but the climate seems to favour the growth of roots and grasses. Around the town of Alberni there is a stretch of good farming land under settlement. Very good land is reported near Cape Scott, where there is a considerable settlement of Daues.

The timber seen in the area covered by this report does not appear to be of much value from a lumberman's point of view. On the exposed part of the coast and along the rocky shores of the arms and bays, owing probably to the lack of soil and to the strong sea winds, which, especially in winter, drive in from the westward and southward, the timber is more or less scrubby and of short grain. One or

Timber.

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two exceptions were observed, namely, at the mouths of the St. Juan and Gordon rivers and at the head of the Alberni canal. A very few scattered and stunted Douglas firs are seen on the coast itself, but some of fair size were observed at the mouths of streams falling into the different arms, and such trees are reported to be plentiful in the interior. Spruce and hemlock, with some cedars and balsams, on the flats form the chief growth of the forest, while sallal bushes and alders form the chief undergrowth.

GEOLOGY OF THE WEST COAST OF VANCOUVER ISLAND.

Professor Ernest Haycock.

GENERAL OUTLINE OF SEASON'S WORK.

On May 31, I left Ottawa with instructions from you to join Mr. Arthur Webster, at Victoria, B.C., and to engage with him in the study of the geology of the west coast of Vancouver island. I reached Victoria on June 7, and Mr. Webster came over from Vancouver on the 18th. The intervening time was occupied in gathering information from mining men, prospectors, and others, in regard to the region to be examined; in collecting from the government offices, and in studying all the maps and literature available relating to surveys on the west coast, and in examining the crystalline rocks and the superficial deposits of the south and east borders of the Victorian peninsula from Esquimalt to Telegraph cove.

On June 21, our party left Victoria with camping outfit, and after about three weeks spent in the Metchosin and Sooke districts, returned to Victoria on July 11.

Dense
covering of
vegetation.

Fairly good roads intersect these districts, and outcrops of crystalline rocks are abundant. Away from the highways, particularly near the coast, the country is exceedingly difficult to traverse. The surface is rough and broken, and the minor inequalities are concealed beneath a dense coating of vegetation wherever the smallest accumulation of soil makes rooting possible.

Deep and almost impassable gullies and abrupt faces of solid rock confront the explorer at almost every turn. Huge standing trees and fallen trunks, which often serve as natural bridges to the ravines, form with their interlacing branches additional obstacles, and with a dense undergrowth frequently higher than the line of vision, geological investigation becomes wholly secondary to the problem of progression.

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On turning to the sea coast, the difficulties are scarcely less formidable. Vertical bluffs, intersected by deep gullies, face the waters of the straits along much of the coast, and stretches of level shore are so rare that the pedestrian may occupy hours in advancing an insignificant distance,

Character of
the sea-coast.

The experiences of the few days spent in attempts to do geological work from the land led to the conviction that examination from the water by boat or canoe was the only method by which satisfactory progress could be made. The Indians too were found to be unreliable, in regard to keeping appointments, if their immediate necessities chanced to have been relieved by the capture of a salmon between the times of agreement and fulfilment. Moreover, as they were reported to be mostly absent from their villages farther up the coast, and engaged either in the Behring Sea sealing or the Fraser River salmon fishing, it was deemed advisable to leave Victoria with an outfit that would allow of regular prosecution of work independent of native assistance.

In pursuance of this plan, on returning to Victoria, a nineteen-foot sealing boat was purchased and provisions for from two to three months were added to the previous outfit. The wisdom of this plan was abundantly demonstrated during the remainder of the season and, with slight exceptions, for the particular work in hand the outfit served every purpose.

Examination
by open boat.

The Pacific coast of Vancouver island, called locally the West Coast forms a broad and regular curve, convex towards the ocean. Its length from Race Island lighthouse, at the southern extremity, to Cape Scott, its north-western, is 250 miles. A straight line joining these extremities lies in a direction 52° west of north, and along its central portion is about 20 miles from the outer coast line. This outer coast line is broken by the entrances of five deep sounds, all more or less choked with islands, and with finger-like extensions radiating among the adjacent hills. Regarding Port San Juan as another of the major inlets, the coast from Race island to Cape Scott is broken at regular intervals of about 35 miles by deep indentations which from south to north are as follows: Port San Juan, Barclay, Clayoquot, Nootka, Kyuquot and Quatsino sounds. The intervening strips of coast, beyond San Juan at the entrance of the strait of Juan de Fuca, are exposed to the full force of the ground swell from 10,000 miles of open ocean, and a heavy surf pounds ceaselessly upon the rocks.

Description of
the West
Coast.

Since it was difficult and even dangerous to make landings for geological examinations upon these exposed stretches of the coast, and also impossible to cover the whole territory during the season, it was

Work done.

decided to apportion the time among the principal sounds and make use of the coast steamer in crossing the exposed portions. In pursuance of this plan one week was spent at Port San Juan, twelve days on Barclay sound, nineteen days on Clayoquot and one month on Nootka Sound. Excepting the north side of Barclay sound the entire shores of the above named sounds and their extensions were studied, and, including the portions examined at Victoria and Sooke, a total coast line of 637 miles was gone over during the summer. A large collection of illustrative material was made, including practically every variety of rock met with, and specimens from every important section of the coast. These will furnish material for chemical and microscopical research, which should aid in the elucidation of some of the problems of the field relations of the metamorphic and intrusive series, and the origin of the metalliferous deposits. Kyuquot and Quatsino sounds were not studied, but the latter was examined by Dr. Dawson in 1885, and his description is found in the annual report of the Geological Survey for 1886, page 81 B.

At the close of the season, the coast steamer was taken on her monthly trip north, and a passing glimpse was obtained of the remainder of the coast as far as Cape Scott. In returning, our party reached Victoria on September 30.

Physical Features of the Region and their Relation to its Investigation.

That part of Vancouver Island over which geological investigation was prosecuted during the season of 1902 consists of the south-eastern two-thirds of the strip of West coast country, bounded by the Pacific ocean on the south-west and a straight line on the north-east joining Race island and Cape Scott. Its length is 245 miles and average breadth about 12 miles. Its superficial area is approximately 3,000 square miles, and that of the portion studied about 2,000.

Rugged surface.

The surface is extremely rugged and broken. Lofty pinnaced peaks and rounded hills, deep ravines and sharp valleys occupy almost the entire area. Yet, just as the coast line when viewed in a broad way forms an unusually smooth and symmetrical curve, so the elevation of its surface forms a curve even more conspicuously symmetrical than that of the coast line. From Race Island light to Barclay sound the hills gradually increase in elevation from a few hundred to about 3,000 ft.; north-west of Barclay sound the elevation increases, reaching its maximum in the snowy ranges of mountains back of Clayoquot and Nootka sounds. Thence north-westerly the peaks become less lofty, seldom reaching 3,000 ft. beyond Kyuquot except in the Cape Cook peninsula, and gradually becoming less elevated towards

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Cape Scott, where the surface becomes rolling and hilly, and in general resembles that of the south-eastern extremity of the island.

Another leading feature of the West coast is the presence of the Deep inlet, large sounds and their extensions previously mentioned as occurring at almost equal intervals from the entrance of the strait of Juan de Fuca north-westwardly to Cape Scott. The wider central portion of the strip of country above outlined is intricately cut up by these arms of the sea, which are without exception deep and perfectly navigable for the largest kind of vessels. Excepting Alberni canal and extension from Barclay sound and Quatsino sound, which lie almost wholly to the north of the imaginary boundary line above indicated, all of these waterways are practically confined to the strip of coast country under consideration.

The existence of these sheltered inland waters was of the greatest importance to the work of the season. Their shores between tides form practically uninterrupted exposures of the country rock, and landing is almost always easy and safe. The admiralty charts are so accurate that almost any point can be located with sufficient closeness for geological purposes, and by them the stranger can navigate with confidence.

Away from the immediate shore line, the obstacles to geological investigation were of the same character as those met with in the Sooke district but on a larger scale. Standing and fallen timber, dense undergrowth, steep slopes, ravines and boulder beds form the normal surface of the country. Where large streams enter the sea, as at the heads of all the larger extensions of the sounds, considerable deltas or detrital fans of level ground are built out, and these small areas are the only exceptions, away from the outer coast line, to the rule of a precipitous and rocky character for the surface.

From Barclay sound north-westwardly along the open coast, a narrow and interrupted coastal plain borders the sea. It rarely or never exceeds two or three miles in width and occasionally appears to exist only in a fringe of low scattered islands or rocky wave-washed ledges, or is wholly worn away by the vigorous marine erosion.

The presence of this less elevated border along much of the exposed ocean front, the consequent absence of lofty and inaccessible cliffs facing the ocean, and the existence of extensive sandy or gravelly beaches, greatly diminish the difficulties usually met with in land travel in this region, and examination of these yet unexplored portions is regarded as most feasible by foot travel along the coast. Landing places where the form of the projecting points or outlying ledges breaks

Importance
of inland
waters.

Coastal plain.

Methods of
examination
advised.

the force of the ocean rollers, are known to the Indians, and in ordinary summer weather the boat and outfit could be sent ahead to such points while the geologist was making the best of his way to the same points on foot. Such a method would obviate the necessity of returning over ground already examined, a matter of much consequence in a country so difficult to traverse. The same plan of progression is wholly out of the question as soon as the open coast is left, from the abruptness with which the land and water meet, but here the absence of the heavy ground swell permits of the more easy and rapid method of examination from a boat.

Coast
south-east of
Cape Beale.

South-east of Cape Beale the coast is of a somewhat different character. The coastal bench is higher, and the sea is faced by lines of trap and sandstone cliffs. Sand and gravel beaches are rare, and between Cape Beale and Carmanah point the sea appears to break directly against the cliffs for much of the distance. Between Carmanah point and Port San Juan a shelf of wave-washed sandstone, passable under ordinary conditions of tide and weather, lies at the base of the coast cliffs. From San Juan to Race island, crystalline rocks face the sea abruptly, and travel along the shore is impracticable for other than short distances. As a rule, diminution of the ocean swell as the strait is entered, lessens the surf so that landing is possible on this section at almost any point in favourable weather.

Coast between
Kyuquot and
Quatsino
sounds.

Between Kyuquot and Quatsino sounds, the character of the coast was not clearly determinable from the steamer in passing, except along the outer shore of the Cape Cook peninsula. With this exception the general appearance of the country warrants the expectation of no unusual difficulty in its examination. The appearance of the coast about Cape Cook was, however, repellent. Tidal currents, and perhaps the nature of the bottom, greatly increase the ordinary ocean swell, which pours its volumes furiously upon the rocks and ledges in wreaths of spray and vapour. The coastal bench seemed very narrow or wholly absent, and the retreating sides of the peninsula were rugged, lofty and forbidding.

Hardships.

With the possible exceptions above noted, examination of the whole West coast appears practicable by the methods outlined with a minimum amount of difficulty and danger. With such a frail means of transportation as an open boat, with this one indispensable adjunct so frequently in contact with the rocks in the necessarily innumerable landings, with the occasional necessity of landing in more or less surf, with contents subject to injury or complete loss through accidental wetting, it will be easily seen that with every possible preparation of provisions and outfit against accident, with experienced assistance, and with the best of judgment, accidents are continually possible; and in

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a sparsely inhabited country where, during the summer season, a boat or canoe, or an inhabited rancherie may not be met with for days or weeks, even a slight physical accident, or an injury to the boat might assume grave importance and imperil, at the least, the results of a season's work.

On the other hand the weather from June until after the middle of September is fine and agreeable. High winds are exceedingly rare, and rains infrequent. Good water is abundant and mosquitoes and flies are seldom troublesome. Game is plentiful and, on Nootka sound, deer were easily shot from the boat when needed. Salmon and cod may be taken by trolling, and trout are found in the streams. Ducks are abundant in the creek-mouths, and berries are found in profusion at every camping place. Added to all this is magnificent and inspiring scenery, a temperature that does not enervate, an exhilarating air, fresh from half a world of open ocean, some of the most stupendous exhibitions of the results of geological forces, and ever new and interesting scientific problems. Amenities.

Geology.

Excepting the examination by Dr. Dawson of the northern portion of the coast from Cape Scott to Quatsino sound and the briefer studies of the sediments regarded as possibly coal-bearing, which form a more or less interrupted strip along the north-east side of the strait of Juan de Fuca, little or no critical study seems to have been given to the West coast rocks. Previous study limited.

Exclusive of the unconsolidated superficial deposits of Quaternary age, rocks of at least four different periods occur. Two of these series are crystalline, two are consolidated but otherwise almost unaltered sediments.

Metamorphic Series.

The oldest of these rock series occupies, almost exclusively, the whole region over which investigations were prosecuted during the season of 1902. The only exceptions worthy of mention are the small areas of typical intrusive rocks, and a narrow coastal fringe of unaltered sediments along the entrance to the strait of Juan de Fuca. The rocks of this series, wherever examined, were highly metamorphosed. As a rule, the alteration is a complete recrystallization of the original constituents. Schistose structure is often present and when very prominent, as in the San Juan area, appears to be connected with a less extreme alteration. Its obscurity or absence came to be regarded as due to more complete fusion and recrystallization. Distribution. Schists.

Crystalline
limestone.

Locally the metamorphic series varies widely in composition, texture and structure. In composition these rocks range from non-calcareous, dark coloured, basic rocks, to light coloured, almost pure quartz rocks. Massive crystalline limestones are frequently intermingled with them. Occasionally the limestones show gradations upwards or downwards, by means of passage beds becoming increasingly argillaceous or siliceous, to the non-calcareous rocks. More often no transition is visible, the contacts being sharply defined. In the majority of cases the sharp contacts were plainly due to intrusion of an igneous rock. In one case beyond the possibility of doubt the limestone was a sedimentary deposit upon the vesicular surface of a lava flow.

Amygdaloids.

The mineral constituents are as variable as the average chemical composition. Almost pure granular quartz rocks occur, often with intimately disseminated fine grains of pyrites. These range by increasing admixtures of clay to the quartz and mica schists, argillites and slates. Pure calcium carbonate rocks occur, now almost always completely crystalline, forming white marbles, and by the addition of various impurities producing coloured and variegated varieties, dark to black limestones, and a wide series of more or less calcareous rocks. Associated with all these and belonging to the same series is a range of more or less feldspathic and hornblendic, well crystallized rocks, generally dark in colour and basic in composition, but rarely light coloured, with free quartz and acid feldspars predominating. In addition are fine-grained and compact rocks in which the minerals can not be identified in the hand specimens. These dark coloured basic rocks are frequently amygdaloidal, the amygdules usually filled with quartz and epidote, and the latter mineral is a conspicuous accompaniment of rocks of this character.

Flow structure
and bedding.

The texture ranges from a fine grain without discernible crystal faces to well crystallized masses showing cleavage faces an inch and more in diameter. No glassy rocks were seen, although this character would doubtless be revealed by a microscopic examination of some of the less altered volcanic rocks. Flow structure in felsitic rocks was frequently noticed, particularly about the northern extensions of Nootka sound. Bedding is not infrequently shown, and is the one distinctive characteristic separating the rocks of this series from the intrusives which they often closely resemble. In some portions it shows the alternations and associations of ordinary aqueous stratification. In other portions it is the more or less massive and irregular layering of successive lava flows.

Paucity of
bedded rocks.

With the possible exception of the slates, schists and traps, between Port San Juan and Sooke basin, in all the region examined none of the bedded portions was sufficiently unbroken and continuous to jus-

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tify an attempt at measurement, or scarcely an approximate estimate of their thickness. The identification of particular horizons in the series has also failed for the same reason, and from the obliteration of the original features that might have served that purpose.

From the geographical extent of these rocks, their moderately high dips wherever the bedding is shown, and the troughs 3,000 to 4,000 feet in depth visibly excavated in their substance, the conviction arises that the thickness of the series must be very great.

In mapping the distribution of this series it often becomes a matter of great difficulty to decide whether the rock in question should be classed with the metamorphic, or with the intrusive series. Where stratification is present, even though it is only the massive bedding of volcanic rocks, there is no doubt. But when this is wholly wanting, the problem becomes a difficult one. The importance of this question, and the frequent necessity for passing judgment on critical cases, led to a close search for criteria apart from stratification that would serve when this characteristic was wanting. Towards the end of the season from repeated observations of many typical occurrences of both metamorphic and intrusive rocks, certain criteria were obtained that are believed to furnish tests by which these series can almost always be separated. The accurate delineation of their boundaries may be of considerable economic importance, as the metamorphic rocks frequently contain ore bodies which by some are regarded as original constituents of the sedimentary or volcanic rocks and not to be looked for in the intrusive series.

Although fossils were carefully searched for wherever the condition of the rocks warranted the slightest expectation of their occurrence, nothing of any palaeontological value was obtained from this series. The limestones of Barclay sound near the entrance of Alberni canal, furnished some poorly preserved organic remains, but no other locality yielded even obscure fossils. Fossiliferous limestone was reported to occur near Sechart in this vicinity, but the locality was not visited.

Dr. Dawson's descriptions of the metamorphic rocks of the northern and eastern portions of the island apply with such exactness to this series of the West coast, that there can be no reasonable doubt of the latter being a continuation of the former. They may thus be considered as belonging to his Vancouver series and mainly of Triassic but possibly, in their lower portions, of Carboniferous age.

The folding and metamorphism of such a vast series of deposits variable in composition, has given rise to rocks that present the widest divergence in point of resistance to denuding agencies. The

result is a deeply incased surface of bewildering irregularity. Up to levels of about 3,000 feet this irregularity has had its sharpness smoothed but its hollows deepened and accentuated by glacial agencies. Above that level the peaks are pinnacled and jagged.

Intrusive Series.

Dykes and sheets.

Rock masses, intrusive in character, are widely and abundantly distributed throughout the territory previously described. Many of these are dykes and sheets, which form in different localities relatively varying but usually small proportions of the whole mass. In composition they vary from dark-coloured basic rocks to light-coloured acid varieties. The basic dykes are most numerous and are believed to be connected with the volcanic masses that form so large a portion of the Vancouver series, and do not call for separate classification in a broad and general outline of the geology. The acid intrusives of this type are in some cases visibly connected with the second group of rocks, to be described. In many other cases they are so near such masses that their origin is not much less certain. For these reasons they may be treated with the intrusive series to which they are so closely related.

Acid intrusives.

Areas of intrusive rocks.

Excepting these occurrences, the areas of unmixed intrusive rocks within the region under discussion are neither large nor numerous. They form both shores of Alberni canal for about six miles northward from the mouth of Nahmint river. A band of varying width is crossed by both of the northward extensions of Kennedy lake, by Tofino inlet and Fortune channel, and occurs in a few small islands near the shore at the northern entrance to Deep pass. From the trend of this band it may be expected to form the north side of Meares and possibly of Vargas islands, but their shores were not examined. The granite area of Alberni canal lies in the line and may be a continuation of the Clayoquot Sound band. If so, it should be crossed by Anderson lake and Effingham inlet, neither of which was visited. Other small areas of similar rocks occur on Shelter arm and Sydney inlet, on Muchalât, Thupana and Port Eliza arms, and Esperanza inlet, in the Nootka Sound district.

Process of fusion and metamorphism.

Dr. Dawson's description of the contact of these rocks with the Vancouver series on the eastern side of the island agrees perfectly with the contacts frequently observed upon the West coast. The process interrupted by solidification has been one of fusion and incorporation of the metamorphic rocks into the acid magma. The series in which this process was operative is of variable thickness, and frequently

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shows all its stages. The angular fragments, in passing out or downwards into the acid rocks, become more separated, lose their angularity, and often pass into irregular sheets, producing a schistose lamination of the blending masses. Considerable areas of these mixed rocks of the contact zone are often met with apart from any visible masses of the intrusive series, and point to the existence of underlying masses of the acid rock, which denudation has not yet revealed.

The typical intrusive areas are made up of light to dark gray rocks, coarsely crystalline in texture even at their contacts. The essential minerals of granite, excepting muscovite, make up the largest portion of the constituents, but their relative proportions are variable. Hornblende is almost invariably present, and usually in great abundance. The rocks of this series are massive, and much less broken and shattered than the metamorphic rocks. Schistose structure is often traceable, occasionally producing rocks that may be termed gneiss. Granitoid rocks.
Gneiss.

The origin of the rock matter of the intrusive series is almost wholly problematical. The absence of the older rocks upon which the Vancouver series began to be deposited necessitates the conclusion that this substance is, at least, incorporated in the underlying and now intrusive masses.

Small areas of granite rocks approaching in composition the typical intrusive series above described, occur near Victoria and in the Sooke district. At East Sooke the copper ores appear to be associated with them. When these areas were first studied, the rocks were all regarded as massive igneous, when they were completely and coarsely crystalline, and schistose structure was absent. As a wider knowledge was obtained of the field characteristics and relations of both series of crystalline rocks, more and more of the massive rocks were regarded as altered sedimentary and volcanic masses. Near the end of the season, by the use of the criteria previously alluded to, rocks which in the hand specimen or in field masses showed no trace of stratification or of schistosity, but presented the usual characteristics of plutonic igneous rocks, were unhesitatingly classed with the metamorphic series. The observations of the season thus produced a complete change of opinion in regard to a large portion of the crystalline rocks of the island. Because of these considerations, and the incomplete study of the areas above mentioned, the data obtained are insufficient to warrant a decision on their geological position. Copper ores
with granites.

Cretaceous Series.

The older series of unaltered sediments occur along Quatsino sound and are touched by the head waters of Alberni canal. They were not Unaltered
sediments.

Carbonaceous shales. identified elsewhere within the district examined. The former areas have been described by Dr. Dawson and the latter by Mr. Richardson. Plant remains were found in concretionary masses of the dark brown and black shales at New Alberni, but no effort was made to trace the continuation of these rocks.

Tertiary Series.

Search for coal. The newer series of consolidated but otherwise unaltered sediments have little in their general appearance to distinguish them from the older Cretaceous sediments, and in consequence have been frequently prospected for the bituminous coal beds that characterize that series. These rocks form a narrow and interrupted marginal band along the strait of Juan de Fuca and a few isolated coastal areas farther to the north-west.

Conglomerate overlaid by sandstone. The basal beds are generally of conglomerate, largely derived from the rocks of the Vancouver series, upon which they rest without disturbance. These coarse basal beds are of variable thickness, ranging ordinarily between 50 and 100 feet. The upper portions are interspersed with beds of sandstone, which at length wholly replace the conglomerate and add 50 or 100 feet to the total observable thickness. The most continuous area of these rocks, extending north-westerly from Port San Juan to and beyond Carmanah point was not examined, except near the former locality, and the aggregate thickness may be greater in this area. At Coal creek, in the Sooke district, richly fossiliferous layers occur in the upper sandstones. Plant remains frequently accompany the shells, and the whole series consists of beach and shallow water deposits.

Fossil-plants and shells. In the Coal creek area, and at Sooke, the consolidated and sometimes concretionary sandstones and conglomerates are overlaid by unconsolidated sands and gravels, and by boulder-clay. These later deposits rest unconformably upon the smoothed surface of the sandstone. Just west of Coal creek, trap rocks come through the basal conglomerates, and the upper surfaces of trap boulders of this conglomerate, still in place in the tough matrix, are striated in a direction parallel with the striae on the exposed surface of the trap beds. The glaciation of the surface of the trap rock does not pass under the conglomerate, but disappears at the line of contact, and the underlying surface there shows the characteristic features of marine erosion. From these observations we can conclude that this series of beds had been deposited, and the portions now visible had reached an advanced stage of consolidation before the end of the glacial period. The indications are also

Traps.

Glacial striae.

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that the ice of that period was a prominent factor in the denudation that has removed from the borders of the strait all but a few small areas in the re-entrant angles of the coast line. These observations in the field are, therefore, in general accord with the conclusions reached by Mr. Merriam on palæontological evidence.*

Quaternary Deposits.

Throughout the region covered by the season's explorations, unconsolidated superficial deposits of glacial or recent age are exceptional occurrences. Almost everywhere the underlying crystalline rocks are bare, or but thinly covered by a coating that can scarcely be called soil, yet offers a foothold for a luxuriant growth of vegetation. Within the entrance to the strait of Juan de Fuca, considerable thicknesses of boulder clay, and associated sands and gravels, appear overlying the Tertiary deposits of Coal creek and West Sooke. These lie in somewhat sheltered positions out of the direct line of glacial movement. Generally in this vicinity as well as further to the north-west, the surface is swept clean of deposits, while the contours show heavy glaciation. The materials necessarily removed from the land surface by this process are not now visible, but the charts give some evidence of their occurrence below sea-level.

Glacial action appears to have been an unusually large factor in the development of the topographic features of the region. The remarkable systems of canals and inlets radiating from the large sounds are old glacier beds, and their great depths are almost certainly due to ice erosion. In contrast with their occurrence and general direction at right angles to the coast north of the entrance to the strait is the remarkably smooth and almost unbroken coast line along the strait, which, like the canals farther north, was a glacial channel but of far greater magnitude. Some evidence from the glaciation of rock surfaces was obtained that points to two periods of glaciation. Traces of the earlier and more extensive ice sheet remain only in the rounded contours beyond the outer limits of the freshly striated surfaces left by the later one. Similar evidence ought to be found on the elevations, which are rounded and smoothed up to and above 3,000 feet, but were not critically examined.

Additional data derived from a study of the charts, when combined with the season's observations, appear to warrant the following conclusions. The submarine coastal shelf has been developed by a process

* NOTE ON Two Tertiary Faunæ from the Rocks of the Southern Coast of Vancouver Island. Bull. Dept. of Geology, University of California. Vol. 2, No. 3, pp. 101-108, 1896.

that has been in operation from a time long anterior to the glacial period. Cape Flattery probably marks the southern limit of glacial action upon the Pacific coast line of North America. The earlier and greater ice sheet crossed the present coast line of Vancouver island, and reached out several miles upon the coastal shelf. The limit of the later ice sheet was within the coast line south of Clayoquot sound, but reached that line on Nootka sound. The ice erosion that so conspicuously scoured and furrowed the present land surface operated very lightly on the coastal shelf. It is believed that the period of extreme glaciation was not one of much, if any, elevation above the present level, since those glaciers that did reach out upon, or (as in the case of the great strait glacier) did possibly cross, the coastal shelf, would have excavated deeper furrows in its surface.

Recent marine deposits and old shore lines.

Recent marine deposits assume some importance in the immediate vicinity of Victoria, where they occur about 30 or 40 feet above high tide. At Friendly cove, on Nootka island, the Indian village is built on recent beach-deposits of about the same elevation, and sea-worn caves, now choked with shrubs, occur above the level of the highest tides a few miles farther west. Borings of mollusks were traced up to about the same level, becoming more weathered and obscure towards their upper limit. Similar borings were also noticed in the sandstone at Tatchu point, and indicate a moderate elevation in comparatively modern times. Above this old shore line, with the exception of the Tertiary shelf previously mentioned, no benches were traceable on the slopes of the hills. Small deltas, partly overflowed by the highest tides, occupy the heads of all the deep inlets, and fans of coarse detritus front the entrances of all considerable streams along their sides. They are the most recent of the deposits and their construction it still in progress.

Economic Considerations.

Timber scarce.

The natural resources of the West coast of Vancouver island are almost wholly undeveloped. The timber visible from the coast is scarcely sufficient to warrant any expectation of its ever forming the basis of a large industry. Small areas of good timber usually occur on the deltas at the stream mouths, and in some cases appear to continue for some distance up the valley bottoms. The area that seemed to offer the best outlook was that of the San Juan valley, which is two or three miles in width and runs back several miles. A lumber camp was established in this vicinity late in the summer, and operations were reported to have begun upon a considerably larger scale than heretofore. About Barclay, Clayoquot, and Nootka sounds the surface of the

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country is so broken, and the stream valleys so narrow that large and accessible timber areas are not to be expected. South of Kennedy lake a considerable area of more level land may prove one exception to the general rule.

The fishing industry of the West coast gives far greater promise than the lumbering. Only one salmon cannery, at the entrance to Kennedy lake, is at present in operation on this whole coast. A second was in operation for a time on Muchalat arm but was abandoned because of lack of fish. Under the present laws relating to methods of fishing, this branch of the industry gives little prospect of development. Salmon occur, however, in all the coast waters in considerable abundance, and the great numbers that annually resort to the Fraser and other adjacent mainland streams are believed to come up the strait of Juan de Fuca along the Vancouver Island coast. Consequently the recent proposal to permit the use of set traps, in addition to the present drift net methods for their capture, resulted in a wild rush to secure locations and every favourable and accessible stretch of shore between San Juan and Race island was staked for this purpose at the earliest lawful date. The future prospects for this method of fishing in all the large inlets farther north is regarded as very promising. Should trap fishing become lawful on the Canadian, as it already is on the United States side of the boundary line, salmon canning on the West coast may become a large and profitable industry.

Salmon fisheries.

Use of set traps.

Very little attention is at present given to the deep sea fisheries of British Columbia. With the increase of population in the central and western portions of the continent, and development of transportation facilities, the demand for this cheap and wholesome food product must become large, and bring about the establishment of fishing villages in the numerous good harbours of the coast.

Deep sea fisheries.

Any immediate or early advance in wealth and industry on the West coast is dependent on its mineral resources. Although the country is still largely unexplored, what is known of the rocks and their associated ores, gives rise to a firm belief in their great value and future possibilities. With respect to their mineral contents, the west coast rocks may be considered in three groups—the crystalline rocks, the consolidated sediments, and the superficial deposits.

Mineral resources.

As has been previously stated, the crystalline rocks occupy nearly the whole of the land surface of the West coast country. The great thickness of these rocks, their diversity of composition and origin, the extreme geological forces to which they have been subjected, their

Ores of the crystalline rocks.

broken and faulted condition, and the extent to which they have been cut by intrusive dykes, sheets, and plutonic masses, are all features regarded as favourable for the occurrence in them of valuable and extensive ore deposits. The navigable inland waters are also highly favourable to the cheap transportation of both supplies and products.

Actual occurrences of ores in these rocks have already been reported from localities too numerous to mention, and a few of these, upon which some work has been done or was in progress, were visited. Brief examinations, and series of specimens illustrating the ore, gangue, and associated rocks, were made at East Sooke, Newton's camp on the Gordon river at San Juan, the Happy John group of claims near the entrance of Alberni canal, and Copper island on Barclay sound.

Iron and
copper ores.

The usual sulphides of iron and of copper and iron, in a hornblende gangue, occur at the Blue Bird claim at East Sooke, the whole immediately associated with massive crystalline rocks, occasionally of very coarse texture. Three or four miles farther south near the outer shore of the East Sooke peninsula, deposits of magnetite occur, with varying amounts of the above named sulphides, associated with what were regarded as the metamorphic rocks. Disseminated particles of pyrite and chalcopyrite are here widely distributed. They occur as constituents of the country rock, as well as in veins and joints. Specks of native copper were also occasionally observable on the joint surfaces.

Native copper.

At Newton's camp on the Gordon river the work was stated to be wholly of the nature of development. Although the ore body was not cut by the shaft that was then being put down, and had reached about 300 feet, magnetite was a common constituent of the crystalline rocks on the dump. The surface outcrop of the ore body was not seen. The rocks along the trail and visible at intervals are of the metamorphic series, and considerable masses of limestone occur in the vicinity.

Alberni canal.

Several groups of claims are located on the north side of Alberni canal near its entrance. Considerable development work was reported to have been done on the Monitor and Hayes groups and some ore shipped. No work was in progress at the time of our visit and only one of the occurrences of the vicinity was examined. The ore at this claim—the Happy John—was a chalcopyrite associated with limestones which were closely intermixed with dioritic rocks. On Copper island, a few miles to the south-west, the ore is a magnetite associated with dioritic rocks. Limestones occur in the vicinity and the ore-bearing rocks appear to belong to the metamorphic series. Other deposits of

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magnetic iron in this vicinity are reported from the Sarita River valley and from Sechart.

A closer and more continued study of these and other occurrences is much to be desired, as, until more accurate and complete knowledge is possessed of some typical occurrences and their field relations, the possibilities and probabilities of discoveries in rocks of other localities are largely matters of chance. Copper island is regarded as one favourable locality for such study of the magnetic iron ores. The coast of the island offers an exposure completely surrounding the area, and a large portion of the surface near the deposit is bare of vegetation. Further examination desirable.

Similar rocks and associated ores occur on Clayoquot and Nootka sounds, and the highest expectations are held that some of the known, and others yet unknown occurrences, will prove extensive and valuable. Nootka sound.

The consolidated sediments of the West coast can scarcely furnish any contribution to the mineral resources of the country. It is possibly otherwise with the area of these rocks about the head of Alberni canal. If this area should be found to contain workable coal beds of considerable extent, the conditions would probably be highly favourable for the establishment of a great industry at that point. With abundant iron ores on Barclay sound and limestone in unlimited quantity immediately upon the water front at the entrance of the canal, and the canal itself forming an ideal highway for water transportation, such a discovery would apparently make up a rare combination of advantages for the economical production of iron. Should the quality and quantity of the Barclay Sound iron ores fulfil the sanguine expectations of the present owners, it does not seem at all unlikely that Alberni may become the seat of such an industry, as coal occurs Ores of the consolidated sediments. not far distant in the Nanaimo and Comox fields, and the intervening country offers no great engineering difficulties to railroad transportation. Coal.

Pleistocene and recent deposits are of such limited extent upon the West coast that they cannot add much to the mineral wealth of the country. The beach sands of Wreck bay, between Barclay and Clayoquot sounds, have yielded some gold, and this is said to have been derived from the superficial deposits immediately to the rear of the beach. With limited exceptions, however, the ice of the glacial period swept off beyond the present shore-line the loose surface materials that had been accumulated previously to its advent, and with them a considerable thickness of the rock upon which they rested, thus eliminating almost all possibility of the occurrence of placer deposits of any extent along the coast. Ores of recent deposits. No gold.

Conclusion.

The field observations of the present summer have probably brought under notice every geological formation of any importance that occurs on the coast, and in part have established their relations. On the other hand, the examinations of the separated areas were not connected, the difficulty in penetrating the country and want of time forbade the tracing of outcrops or contacts of any formations away from the shore, and the rocks being mainly crystalline, closer study by chemical and microscopical methods should supplement the field examination. Because of these considerations the conclusions reached need not be regarded as final. Still, it is thought best to state them, along with the recorded observations, as more or less probable working hypotheses suggesting and stimulating further investigations.

PRELIMINARY REPORT ON THE BOUNDARY CREEK DISTRICT,
BRITISH COLUMBIA.

Mr. R. W. Brock.

Introduction.

On May 29, I left Ottawa with instructions to first make a detailed survey of the Boundary Creek district, and then to make a reconnaissance survey of the West fork of the Kettle river. I was accompanied by Mr. W. H. Boyd, of this office, who took charge of the topographical branch of the work. Greenwood, as the central town of the district, was selected as headquarters for the season. The area embraced in the Boundary Creek map-sheet is that lying north of the International boundary line and south of Pass and Lost creeks, between the North fork of the Kettle river, and a line from a little west of Midway north between Copper and West Copper camps. Within this area lie all the mining camps of the Boundary Creek district at present being worked or opened up. The work was done in sufficient detail to enable an accurate map, on a scale of one mile to the inch to be constructed. The uniform elevation of the mountains, the frequent forest growth on their summits and the irregularities in the topography made it necessary to take a very great many transit stations. The intricate mixture of many different rocks of different ages made the geological work difficult and slow, so that more time was consumed in the survey of the sheet than had been anticipated. The season was hot and dry. In the latter part of August the daily range of temperature was very great, extremely hot days succeeding frosty nights. Just before completing the map sheet, toward the latter

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part of August, the sun proved too much for me and I was ordered home by the doctor. This made the intended reconnaissance survey of the West fork of the Kettle river impossible. I remained in camp, however, to look after the completion of the geological work on the Boundary Creek sheet, returning to Ottawa on Sept. 22. Mr. Boyd remained in the field two weeks longer to complete the topographical data.

The Topographical Map.

The method employed by Mr. Boyd in the topographical work was triangulation by means of numerous transit stations, with careful sketches drawn to vertical and horizontal scale, commencing from a base surveyed along the railway spur on the midway prairie. This triangulation was tied on to the International boundary monuments, to mineral monuments and to stations used in the West Kootenay sheet east of the North fork of the Kettle river.

The triangulation was supplemented by numerous road and trail odometer and paced surveys between fixed points, using prismatic compass and aneroid barometer. Similar traverses were made of numerous ridges and valleys. With the exception of some of the traverses, all the topographical work was done by Mr. Boyd. He also rendered material assistance in the completion of the geological work after my illness.

A reconnaissance survey of part of the district was made last year, and its general characters are described in the Summary Report for the year.*

Physiographical Features.

The area covered by the Boundary Creek sheet possesses the characters of an older mountain district. The mountains have been worn down below the limit of intense Alpine erosion and appear as rounded ridges or dome-shaped summits of a rather uniform elevation of about 5,000 ft. The uniformity in elevation of the mountains cannot here be taken as indicating that the country is a dissected peneplain.

It is due to the wearing down of Alpine peaks by erosion. Above ^{Plain of erosion.} the tree line when frosty nights succeed hot summer days and the rocks are unprotected by soil or vegetation, the erosion is intense and the mountains wear down rapidly. As soon as a ridge or mountain is cut down to the base of this zone of rapid erosion, its degradation

* Summary Report of the Geol. Survey for the year 1901, pages 49-67.

becomes very much slower, while the peaks still standing in this zone continue to be heavily attacked so that they are in turn cut down to the base before the former have retreated much below it. Consequently about tree line and for some distance below it, the mountains and ridges may possess a rather uniform elevation, as is the case in the present map-sheet. But while the regularity in form or elevation is mainly due to erosion, it is in part due to the filling up of old irregularities in the surface by the Tertiary lavas which once covered the entire surface of the sheet and which still may be found capping many of the ridges or frozen to their flanks. Glacial erosion may also have been effective in reducing inequalities in the surface relief. The valleys form a well marked longitudinal and transverse system. The North fork of the Kettle river and Boundary creek are longitudinal valleys. The transverse valleys are off-sets from these. The valley of the main Kettle river which merely touches the S. W. and S. E. corners of the sheet, forms in this part of its course an important exception, running across the general trend of the mountain ranges and primary valleys.

Modification
through
glaciation.

The west arm of Kootenay lake and the river from it to the Columbia in the West Kootenay map-sheet furnish an illustration of a similar irregularity. While in general the structure, form and elevation of the mountains are regular, in detail they are more or less complex and irregular. Owing to differences in the resistance of different rocks to the agents of erosion, the ridges are often notched or rise into elevations, breaking the regularity of the distribution of summits. There have been important changes in the drainage, brought about by one stream eroding backward and capturing waters of another, and in other ways. Probably the chief factors in these changes have been the Cordilleran glacier which scoured this country and local remnants of it, though it is often difficult to say just what has resulted from ordinary river erosion, what from glacial erosion and what from differential uplifts. The most obvious effects of glacial erosion have been the straightening of valleys, with a tendency to produce longitudinal valleys (these have the general course of the glacier), the alteration of the V-shaped valley to the wide U-shaped valley, and the truncation of the ends of ridges between adjoining transverse valleys. The glacier also deepened the main valleys. The deepening of these main valleys, coupled with the truncation of the ends of spurs separating lateral valleys has produced many hanging valleys. That is the beds of many of the transverse valleys are high above the floor of the trunk valleys, so that the streams occupying them debouch in waterfalls or have been forced to cut canyons down to the level of the trunk

Hanging
valleys.

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stream. The little tributaries of the North fork of the Kettle from the west almost all occupy lofty hanging valleys.

The bottom of Boundary Creek valley is considerably above that of the main Kettle river, so the creek is cutting a canyon back from its mouth. Boundary Falls is at the head of this canyon.

The character of these valleys while not so marked as in the main valleys of West Kootenay, is still distinctly fiord-like, and this character is to be attributed to glaciation. In the case of many of the creeks a narrow canyon-like trough has been cut in the widened valley bottom since the ice vacated it. Brown creek, in whose valley a great deal of glacial material has been deposited, has cut its trough, not in the deepest part of the rock bottom, but along the north side of the valley.

The creeks occupying hanging valleys have generally built up alluvial fans where they discharge into the deeper valleys. A good example of such a cone of dejection is seen in Eholt Creek valley where the torrent from Long lake enters. As examples of changes in the drainage due to the combined efforts of ice and river erosion, Long lake and the North fork of the Kettle may be mentioned. The North fork, even in post-glacial times, flowed west of Observation hill, as pointed out in the Summary Report for 1900. A small lake occupies a portion of its old channel and the depression of its bed on the Grand Prairie flat west of the town of Columbia can be distinctly traced. At present it flows east of Observation hill. The glacier probably cut down the neck of rock joining Observation hill to the mountains to the east in a sufficient degree to permit river erosion to do the rest. Long lake formerly discharged into Pass creek. A saddle-shaped ridge probably divided Pass Creek waters from the Eholt slope. This the glacier cut down to a wide, almost level col. A deposit of gravel probably morainic on the Pass Creek slope caused Long lake to form. At first it discharged down Pass creek, but a small tributary of Eholt creek by headward erosion tapped it and reduced its level slightly so that now it forms a part of the drainage system of Eholt creek. The lake is deepest near its Pass creek end (a little over 64 feet), is separated from Pass creek by the gravel deposit which is about twenty feet higher than the lake level and sloped towards Pass creek. Marshes occur on it which still drain into Pass creek. Numerous examples might be cited of drainage alteration but these will be discussed in the general report.

Changes in
drainage.

The gradient of the main valleys is low, except where they empty into a more deeply trenched valley. The transverse valleys are

usually steep at the head, of low gradient along the middle reaches, and very steep again as they near the trunk valley.

Glaciation.

Other evidences of glaciation beside the form of the valleys are to be seen everywhere. Erratic boulders are perched on the sides and summits of the mountains. Often, for example, granite boulders of great dimensions are to be found lying on volcanic rocks. In many cases the ice has carried them across wide and deep valleys. Some must have been transported a great distance but the majority can be traced to their origin, not many miles from their present position. They have as a rule travelled a little east of south. Polishing and scoring by the glacier are to be seen in many places, sometimes even on the ore bodies. The direction of the ice movement as shown by the striation on polished surfaces of the rocks, is influenced by the local topography, the ice having a tendency to move in the direction of the principal valleys. On the summits of ridges and mountains, it shows greater independence. It varies from S. 15° W. to S. 41° E. An average of a great number of readings gives S. 18° E. as the general direction of flowage. (These readings are astronomic—the magnetic variation is 24°.) The ice sheet which covered this part of the country was no doubt part of the Cordilleran glacier which was shown by Dr. Dawson to have travelled in a direction of S. 30° E. in the Kamloops district,* and which has been proved to have had a similar course over the Kootenay district.†

Boulder clay was not observed in the Boundary Creek district but resorted glacial material is widespread. It is frequently found as terraces of gravel, sand, silt and beds of clay skirting the hill sides along the main valleys. In favourable locations the terraces may extend to a height of at least 2,000 feet above the valleys. Good examples of these terraces may be seen on Boundary creek and the Kettle valleys.

On the hill west of Boundary creek near its mouth, terraces extend almost to the summit of the hill; at least fourteen are plainly visible.

Drift and wash cover a large part of the district, the rocks to a large extent protruding as knees and elbows.

Ranch lands.

The terrace flats on Boundary and the Kettle valleys afford good ranch lands, though irrigation is sometimes necessary. For this purpose the numerous streams are valuable. The open hill-sides, which are not infrequent, afford good grazing ranges.

* Annual Report Geol. Surv. Can. 1894, Part B. † Summary Reports, 1898-9-1900.

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The northern slopes of the mountains and the narrow valleys, are generally well wooded, except where they have suffered from forest fires. Southern slopes are often open and grassy.

Eastern and western slopes may be forested, park-like or open. Forest. The main Kettle valley is for the most part open prairie. The southwest corner of the district is more open than the remainder. The northern part, where the mountains are rising to more rugged peaks, is for the most part tree-covered.

The tendency is for narrower valleys, or summits to be wooded and the hill-sides to be open, owing to the greater precipitation on the summits, and the irrigation by streams in the valleys.

Timber for mining is usually to be had in the vicinity of the mines. Larch, hemlock, fir, spruce and pines are the most abundant trees. The open hill-sides support a luxurious growth of bunch grass. Near Midway the climate is somewhat drier and sage brush, prickly pears, and sand roses make their appearance. The vegetation as a whole is similar to that of West Kootenay outlined in the Summary Report for 1900.

SOLID GEOLOGY.

While for a mountainous district travelling is easy, prospecting and geological work is made difficult by the extreme variety and complexity of the rock formations and the widespread covering of wash. Sedimentary, pyroclastic, igneous, both plutonic and volcanic, and metamorphic rocks all occur, of from possibly pre-Palaeozoic to Middle Tertiary ages.

The geological formations met in the district, and their approximate or relative ages in descending order, are as follows :

Glacial and recent deposits.

	{ Volcanic flows, andesites, basalts, &c.	Formations represented.
Tertiary.	{ Injections of intrusive sheets, dykes and plutonic masses. Ore deposits, volcanic flows.	
	{ Tuffs, ash beds, volcanic conglomerates, sandstone and shales with a little lignite.	
	{ Granodiorite.	
Jurassic ?	{	
Post-	{ Serpentine.	
Palaeozoic ?	{ Green porphyrite.	
	{ Green porphyrite.	
	{ Volcanic conglomerates, tuffs, ash beds with arenaceous limestone.	
Palaeozoic ?	{	
	{ Serpentine.	
	{ Limestones, argillites, quartzite.	

Crystalline schists ? Gneisses and schists.

Except the Tertiary tuffs, sandstones and shales, which yield a few obscure forms, none of the rocks are fossiliferous, so that the geological ages as here given are subject to revision. They have been determined by stratigraphical relationships and the striking resemblances of the lithological units to those found in the Rossland and Kamloops districts, where their geological horizons have been fixed by palaeontological evidence.

The crystalline schists.

The oldest rocks of the district are the crystalline schists and the sedimentary rocks. In the south-east corner, a limited amount of crystalline mica and hornblende schists with interbedded crystalline limestones are exposed. These rocks have a strong lithological resemblance to the Archæan rocks of the Shuswap series, and are the oldest rocks found in area covered by the present map-sheet, but they may possibly be more highly metamorphosed argillites and limestones such as are found elsewhere in this district.

Limestone and argillite.

The limestones, argillites and quartzite, cut by serpentines, form a series which closely resemble the Cache Creek series (Carboniferous) of the Kamloops district. They occur in areas of greater or less extent in almost all parts of the district. They are always more or less metamorphosed; the limestone is generally white and crystalline, although occasionally a core of black or drab limestone is to be seen; the argillites are or were somewhat carbonaceous but are frequently altered. A hornblende or mica schist found in the Long Lake region seems to be an alteration form. Frequently both the limestone and argillites are altered by silicification which, when complete, produces a quartzite-like rock. In the argillites, quartz films and bands are often found parallel to the fissility. Some apparently true quartzites occur. The rocks also show the effects of mechanical deformation. The limestone is in places brecciated. These sedimentary rocks are among the oldest in the district. They are cut and greatly disturbed by the later intrusions of eruptive rocks so that little can now be determined regarding their thickness and original stratigraphical relationships. They seldom form large continuous bands but generally appear as islands of greater or less extent in the intrusive rocks. They probably form parts of a once extensive series of sediments which covered southern British Columbia.

Serpentine.

The serpentine occurs as bands and masses cutting these sedimentary rocks. The intrusive nature of the serpentine is shown in the way in which it cuts across the bedding of the older rocks and in the contact metamorphism it produced. In places traces of the structure of the

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original eruptive rock can be made out in the serpentine. In Central camp the serpentine is occasionally somewhat fibrous, approaching asbestos. Near the Koomoos-McCarren Creek divide it seems to pass into a soapstone or talc. Often it is altered to a rusty aggregate of dolomite (and perhaps other carbonates) and white quartz veins. It is doubtful if all the serpentine in the district is of one age. Boulders of serpentine are found in the green volcanic conglomerates which would indicate that some of it was older than these pyroclastic rocks. On the other hand, some of it seems to be intrusive in the green porphyrite which is of a little later age than these volcanic conglomerates. The serpentines are found in Smith's, Wellington and Summit camps and the country to the south. They are particularly abundant in Attwood and Central camps.

The older pyroclastic rocks and porphyrites are widespread; in fact they are the commonest rocks in the district.

This series of rocks consists of green tuffs and volcanic conglomerates and breccias, fine ash and mud beds, flows of green porphyrite, and probably some interbedded limestones and argillites. The tuffs, conglomerates and breccias consist of a mixture of pebbles and boulders of porphyrite material with a great many fragments (probably a large proportion) of the rocks through which the volcanics burst. Pebbles and boulders of limestone, argillites, jasper and chert are common. Such of serpentine and old granite and old conglomerates are much rarer. In form the pebbles and boulders are rounded, subangular, angular and of irregular and fantastic outline. Sometimes they are somewhat sorted but often they are tumultuously arranged (agglomeratic). Beds of mud, ash and tuff alternate rapidly with coarse volcanic conglomerates and agglomerates. Sometimes the matrix seems to be formed of porphyrite injected between the boulders. Limestone, now crystalline, seems occasionally to have been interbanded with them. It is often arenaceous, bands containing rounded sand grains and pebbles alternating with pure limestone. The sand and pebbles are well sorted and these arenaceous bands are sharply defined from the pure limestone. The matrix of these bands is white crystalline limestone. Argillites are also interbanded to a limited extent, although it is not always possible to distinguish the volcanic muds from such sedimentary material.

Porphyrites
and volcanic
conglomer-
ates.

The porphyrite seems to be a little later than most of the pyroclastic rocks although some of it may be interbanded. Owing to the alteration in these rocks through mountain building processes and contact metamorphism, it is not possible to separate the porphyrites

from the pyroclastic rocks, on the map. The porphyrite is usually too highly altered to make out its original character, but it seems to have been an augite-porphyrine similar to that of the West Kootenay district. In places it is agglomeratic.

Origin of rocks
difficult to
trace.

The great changes produced by mountain building processes and later igneous intrusions, make it difficult or impossible to discover the history of these rocks. The first part of this period of volcanism seemed to have been one of heavy explosions with periods of sedimentation, and to have been followed by a period of more quiet lava flows. The amount of material extruded must have been very great.

A very striking feature in these rocks is the way in which islands or irregular masses of the older sedimentary rocks appear in them. In part, these are included fragments, in part they may represent infolded masses in truncated anticlines, or inequalities in the surface on which this old volcanic series was deposited. Appressed anticlines and faults can be seen in them, but the grand features of their structural relationship are lost through the effects of the later igneous intrusions. Some of the limestone inclusions are to be explained as squeezed intercalated beds. Under pressure, the limestone flows and from a thin bed a line of inclusion-like lenses may be formed. This series of pyroclastic and volcanic rocks seem to have been formed immediately after the sedimentary series, and is therefore probably Paleozoic. In the Paleozoic formations of the Kamloops district, also, green effusive rocks occur.

As already remarked some of the serpentine appears to be of later age than this series.

On the west end of Baker mountain and at the head of Fisherman creek a tough green porphyrite occurs which seems to overlies the sedimentary rocks and old green volcanic and pyroclastic rocks. It looks fresher than the old green porphyrite, and may represent a later eruption. It is an agglomerate in places.

Granodiorite.

At various points throughout the whole district bosses, irregular masses, and dykes of a light gray granitoid rock make their appearance. It is a quartz-bearing biotite-hornblende rock, in places apparently granitic, in others rather dioritic. It is probable that it will prove to be, generally, a granodiorite. It sends out numerous dykes throughout the country, especially in the southern portion of the district. These have usually a porphyritic structure with a microgranitic groundmass. Some are granite porphyries, but a great number are quartz-diorite-porphyrines, as are also some of the smaller

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bosses. On McCarren creek, north side, are some basic hornblende gabbro-porphyrific dykes which may belong to the same intrusion. In places these shade off into pure hornblende rocks.

This granodiorite is evidently intrusive, cutting all the rocks above mentioned. The mechanism of its intrusion is extremely interesting, for it unquestionably forced its way up through the overlying rocks by digesting them and rifting off fragments. This is proved by its contacts, both along the sides and roofs of the masses. These are, except in the case of the dykes, rarely sharply defined, but are irregular and suture-like. The intrusive holds inclusions of the surrounding rocks, and the surrounding rocks are often filled with granite material. The composition of the intrusion seems to be affected by the digested material of the rock into which it has forced itself. It is also shown by the way in which the granodiorite is exposed in small, more or less circular but irregularly bounded masses, in different parts of the district, such as in Wellington camp and on Hardy mountain. In many cases no definite boundary can be assigned to the granitic mass. From the way in which the rock makes its appearance in all parts of the district, it is evident that the whole of it, at no great depth, is underlain by this rock. This rock has some strong resemblance to the Nelson granite of the Kootenay district, both in composition and in its relationship to the surrounding rocks. The Nelson granite, which has been carefully studied, is a sort of granite representative of the Monzonite group of rocks, intermediate between the alkali and the lime-soda series of rocks, and about on the boundary line between granite and diorite. Its composition is as follows:—

SiO ₂	66.46	TiO ₂	0.27	Al ₂ O ₃	15.34	Fe ₂ O ₃	1.68
FeO	1.83	CaO	3.43	MgO	1.11	Na ₂ O	4.86
K ₂ O	4.58	H ₂ O	0.29	P ₂ O ₅	0.08	—Total 99.93—	

—Analysis by Dr. F. Dittrich, Heidelberg.

The Boundary Creek rock will be found on analysis to contain a greater percentage of alkaline earths, but this may be due to the material it has acquired from the rocks into which it has been intruded, and may represent only a local peculiarity. As the Nelson granite occurs to the north and east of this district and probably also to the west, the Boundary creek rock in all probability belongs to the same great intrusion. If so, its age will be about Jurassic. This agrees with its stratigraphical position in this district.

The remaining rocks of the district are of Tertiary age, with the possible exception of a few dykes whose age is uncertain. These rocks,

which occur in great abundance in the district, are for the most part of igneous origin. They prove that this part of the country, as well as other portions of southern British Columbia, where they also occur, was the scene of tremendous volcanic activity during Tertiary times, comparable in magnitude with that of Idaho, Washington, Oregon, etc.

Stratified
rocks.

The oldest Tertiary rock is a coarse conglomerate which occurs on Baker and Thimble mountains. It is a coarse conglomerate containing boulders of all the older rocks of the district with some of volcanic origin. It resembles the basal conglomerate underlying the volcanic rocks of the West Kootenay district* and may perhaps correspond to the Coldwater group of Oligocene age of the Kamloops district. It is probably of fresh water origin, and may represent an old river bed. Overlying this conglomerate, but in many places resting directly on the older rocks, is a white gritty tuff, consisting largely of fragments of quartz and feldspar, with a little calcareous and ash matrix. This rock is locally known as 'sandstone,' and also as 'porphyry.' It is much more widespread than the conglomerate. In Copper camp, near Ingram creek, some sandstones and shales occur holding fossil plants

Lignite coal.

altered to lignite. In Copper camp these are scattered through the rock, but on Ingram mountain a bed several feet thick of lignite occurs. Here some sheets of lava are interbedded with the sandstone, but generally the lavas are younger and overlie the pyroclastic or sedimentary rocks, where these occur, or rest directly as a capping on the pre-Tertiary rocks of the district.

Lavas.

The volcanic flows are present in great thickness. In composition they vary from a dark heavy olivine-bearing basalt to light coloured andesites, dacites, trachytes and possibly rhyolites.

The earlier eruptions were evidently from local vents and explosive in their nature, as shown by the beds of tuffs and their irregular distribution, and the occurrence of volcanic plugs at Phoenix, near Summit City and on Thimble mountain. These are, however, not the earliest vents as they pierce the gray tuffs and the lower volcanic sheets.

The later volcanic flows, from their wide distribution and absence of tuffs, have probably come from fissure eruptions.

The basic lavas are often amygdaloidal or scoriaceous. The vesicles are often filled with chert, agate or zeolites.

*Summary Report for 1900, pp. 67, 70, 74.

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The basalts are often coated with a green material which prospectors have mistaken for copper carbonate. It appears to be largely manganese, copper being entirely absent.

These volcanic rocks are similar to those described in the West Kootenay district* and in the Kamloops district.† Dr. Dawson subdivided the Kamloops volcanics into a lower and upper group, both of Miocene age. This subdivision cannot be made in the Boundary Creek district, nor was it feasible in the Shuswap district.

These rocks which once formed a continuous capping over the whole of the district, except perhaps the highest peaks, have been dissected by the streams and now occur for the most part as isolated outliers on the tops and sides of ridges. This is their mode of occurrence at the northern and eastern parts of the sheet. They form an almost continuous capping among the range west of Boundary creek to the International boundary line, though cut through by Wallace creek, partly cut away by Copper creek, and in some places by the Kettle river.

Some of the little remnants of these volcanic rocks are too small to map.

Their occurrences in Copper Creek valley, in Jolly Jack creek valley and Kettle river valley, far below exposures of older rocks, prove that these were valleys in early Tertiary times.

The attitude of these rocks, however, prove that mountain-building forces were at work after their extrusion. In places the tilting of the beds might be explained by deposition or solidification on an inclined surface, in others as near as Eholt on the Columbia and Western railway, where they form a syncline trough, it might be explained by the intrusion of the alkali-syenite rocks described below. But on Copper creek where the volcanics and underlying sandstones are tilted sixty degrees or more to the east, neither of these explanations will apply. So that it is certain that considerable movements of the earth's crust occurred here in Middle Miocene times, if not later. The ore-bodies, which as will be shown later, were formed about the same time, would be subjected to the same movements.

Besides the volcanic plugs, such as those at Phoenix (which cut the tuffs and lower volcanic sheets, and whose material is identical with that of some of the basic flows) bosses, dykes, intrusive sheets and possibly surface flows of alkali-syenite material occur, which are newer than at least the lower members of the Tertiary volcanic group.

*Summary Report, 1900. †Annual Report, G. S. C., 1894, Part B.

Alkali
syenites and
alkali syenite
porphyries.

Where occurring in a boss or large dyke the rock is medium to coarse grained, pink to grayish, consisting largely of feldspar of somewhat glassy habit, some biotite and a little diopside and hornblende, with accessory apatite, magnetite and titanite. A little nepheline and sodalite also occur in it. The feldspars are microperthite and albite, with perhaps anorthoclase. They are sometimes idiomorphic with a tendency to arrange themselves in parallel alignment or radially around a bisilicate. The bisilicates form but a small percentage of the rock, and of these biotite is the most important. The hornblende is a bluish green variety with high extinction and strong dispersion. In the powdered rock a blue mineral with the characters of riebeckite was detected, so that this hornblende is probably an accessory mineral.

This rock is an alkali syenite, probably of the Pulaskite type. In the smaller dykes it has the structure of a porphyry and is therefore in such cases, an alkali syenite porphyry. The groundmass is often very finely granular and the phenocrysts are rosette-like aggregates of feldspar crystals with an occasional one of biotite.

There are also dark lamprophyric dykes and light bostonite-like dykes which are probably connected with this rock.

Analysis of
pulaskite.

This alkali syenite or pulaskite is the same rock as the Rossland syenite that is widespread over the western part of the West Kootenay district.* An analysis of the latter gave the following results:—

Si O ₂	62.59
Ti O ₂	0.54
Al ₂ O ₃	17.23
Fe ₂ O ₃	1.51
Fe O	2.02
Mn O	Trace
Mg O	1.30
Ca O	1.99
K ₂ O	6.74
Na ₂ O	5.50
P ₂ O ₅	0.11
H ₂ O direct	30
C O ₂	Trace
Cl	Trace
S O ₃	Trace

99.83—Analysis by Dr. F. Dittrich, Heidelberg.

* Summary reports, 1898-1900.

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This analysis agrees closely with those of previously described pulaskites.

The alkali syenite bosses and dykes are particularly numerous in the northern half of the Boundary Creek district. North of the sheet is a large area of it. They are newer than and intrusive into all the rocks of the district with the possible exception of the latest volcanics. The most common mode of occurrence in the map-sheet is as porphyry dykes or intrusive sheets, but some horizontal sheets exposed on the surface may have been surface flows, and some of the lavas seem to have about the same composition. From their relationship to the volcanic rocks it is probable that the latter are alkaline in composition and that the alkali syenites plug the vents through which the later flows reached the surface.

Besides the rocks above described some dark basic dykes occur which seem to be connected with the volcanics.

The distribution of the various rocks will be shown on the map and need not be described here.

Distribution
of rocks.

The commonest strike for the sedimentary rocks as well as for the various dykes is about N. and S., but many exceptions occur, as is natural in an eruptive area.

THE ORE DEPOSITS.

The ore bodies may be divided into three groups. (1) The large low grade copper-bearing deposits, (2) Oxydized copper veins, (3) Gold-bearing and silver-bearing veins.

Low Grade Copper-bearing Deposits.

According to the form of the deposit this group might be subdivided into—

(a). Huge bodies, of as yet unknown form, and dimensions, as the Mother Lode, Knobhill-Ironsidles. In the Mother Lode the ore, as tested, outcrops for 2,000 feet. The average width is about 140 feet, (though the walls are not natural but rather commercial) and the ore is continuous to the bottom workings, at present 500 feet below the highest point of the vein. The Knobhill-Ironsidles lead, extends practically throughout the length of both claims (3,000 feet) and probably into the Gray Eagle. The ore has been proved 800 feet below the highest point of the vein. The west or foot-wall is definitely known

Low grade
ores.

but the hanging wall or what may correspond to it has not yet been reached. One stope is 21 sets wide and 100 sets long (7 feet centres), which will furnish some idea of the size of the ore-body.

(b). Bodies of more or less lenticular form, generally occurring in groups or as ore chutes, in vein-like bodies as in the Brooklyn and Stemwinder, and B.C. mines.

(c). Smaller veins.

**Ore-forming
minerals.**

According to the chief economic minerals in them, these deposits may be subdivided into a pyritic type, in which pyrrhotite, chalcopyrite with some pyrite are the chief economic minerals; and a magnetitic type in which magnetite, chalcopyrite with some pyrite and specular iron are the chief minerals. Excepting that the pyrrhotite of the one is represented by magnetite in the other, these two types appear to be identical. Both the magnetite and the pyrrhotite replace the constituents of the country rock in the same way, both seem to have been formed, on the whole, a little prior to the other vein minerals, holding them in little veins or as points scattered through, yet sometimes interbanded with them. They are both accompanied by the same accessory and gangue minerals and the country rocks show the same alterations in both cases. Rarely do both the pyrrhotite and magnetite occur in the same deposit. In the Old Ironsides and Mother Lode pyrrhotite is, however, present, and in one or two small veins, as on the O. P. and Wolverine claims, both are found. The B.C., Maple Leaf, Winnipeg, Lake and Morrison, may be mentioned as representatives of the pyritic type, while the Knobhill-Ironsides, Mother Lode, Sunset, Brooklyn, Snowshoe, Oro Denoro, Emma and R. Bell belong to the magnetitic type.

It might be remarked that this pyritic type has not yet been found in such large masses as the other, but that the magnetitic type is common in all forms.

Besides the metallic minerals already mentioned, marcasite is occasionally present and, rarely, arsenopyrite, galena, zinc blende and molybdenite, but these are in all cases subordinate in quantity. Tetraehedrite has been found in the City of Paris, and bismuthenite occurs in a specimen obtained at the Bluebell.

**Metasomatic
replacement.**

The ore, for the most part, has replaced the country rock (metasomatic replacement). On the outskirts of an ore body this substitution can often be seen in all stages of development, the individual constituents of the country rock being one by one replaced. The mineralizers

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must of course have followed fractures in the rock, or the line of contact between two rocks when more than one rock is present, and these have also been filled with ore, but the main development of ore has been in the rock itself. Sometimes a fracture-plane, sometimes an impervious rock such as a dyke of diorite-porphyrity or a contact of compact crystalline limestone will form a containing wall to the deposit, but very often there is nothing resembling walls, the ore being irregular in form and gradually shading off into country rock. From the nature of the bodies, altered country rock will form the gangue-stone. In the alteration of the rock, garnets, epidote, amphibole, tremolite, vesuvianite, may be produced and the rock may in addition be silicified and calcified. The calcite occurs well crystallized, in large masses, in little seams or disseminated through the ore and rock. It is seldom found in those parts of a deposit in which magnetite is heavily concentrated. Quartz is often abundant, occurring in the same way as the calcite. Silicification of the country rock to a cherty or quartz-like (jasperoid) mass is a frequent though not invariable phenomenon in the neighbourhood of a deposit. Garnets, epidote and amphibole are very abundant in and near the deposits. They occur both well crystallized and massive, often inter-banded with the ores and forming a large percentage of the material mined.

All the minerals in the deposits appear to have been formed almost contemporaneously. They are often banded. Where there is a slight difference observable, the minerals like garnet and epidote are often formed first and the magnetite or pyrrhotite before the pyrite and chalcoppyrite, but the periods of formation of the different minerals in all cases overlap. The minerals are not evenly distributed, but while sometimes mixed are often bunchy. Magnetite and calcite seem to be inversely proportional—where magnetite is plentiful calcite is sparse, and *vice versa*. Paragenesis.

The ore may occur in any of the rocks except the Tertiary, and even the Tertiary sandstone or tuff, underlying the lavas south of Copper creek, shows some mineralization. The deposits are most numerous, are largest and most valuable in those parts of the district most disturbed by Tertiary volcanism. Limestone in such cases seems favourable for the deposition of ores. In a few instances the ore occurs in the limestone itself, but more frequently it is found in a rock along its contact with limestone. The old porphyrites, or porphyrite-tuffs, breccias or conglomerates (which we will refer to, collectively, as 'greenstone') are the commonest rocks in such cases. The rocks mineralized.

Limestone as
country rock.

It is only fair to state that several eminent observers have considered the greenstones to be altered limestone, and have consequently concluded that a characteristic feature of these deposits is their occurrence in limestone. Emmons holds this view, although he recognizes the pyroclastic nature of the Ironsides rock*. Since the rocks are usually altered and the minerals produced are those common in metamorphosed limestone, it is natural that without a close study these rocks should be considered altered limestones. That they are not altered limestones but altered volcanic and pyroclastic rocks is established by detailed field study and the examination of thin sections. Moreover, it is found that the limestone becomes white or crystalline, with some silicates developed, but is not, as a rule, subject to the same degree of alteration as the greenstones, and that thin bands and tiny inclusions of it in the greenstones preserve their identity, even when that rock is greatly altered. Hence it is usually an easy matter to establish the boundaries of a limestone mass, and it is found that the limestone masses while very conspicuous and somewhat numerous are, as a rule, of very limited extent.

Limestone
contacts
favorable.

The contact between limestone and the porphyrites or pyroclastic rocks seems, as observed above, to be a favourite location for the deposition of ores, and in such cases the ore seems to have a distinct preference for the greenstone.

The lack of mineralization in the limestone may be due to the fact that the limestone often flows and forms compact lenticular masses, instead of fracturing under pressure, and thus furnishes no channels for the mineralizing solutions. If attacked and replaced by them it must have been along the contacts and this must have taken place comparatively evenly, leaving a clean-cut unmineralized wall.

In the case of large deposits along such a contact, it may be difficult to prove which rock is replaced. The fact that clean ore lies along unchanged white limestone, the limestone forming a well defined wall, while the ore and gangue minerals wander off and disappear without any line of division in the greenstone, would make it appear that the greenstone was the rock which suffered greatest replacement. But in many cases, as in the Snowshoe and the B. C., the original structure of the porphyrites or pyroclastic rocks can be seen in the ore. But the strongest evidence of the selection by the ore of greenstone rather than limestone along a contact is obtained in small deposits, where the alteration has not obliterated the actual contact. In such

* *Genesis of Ore Deposits*, 2nd edition, American Institute of Mining Engineers, page 760.

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cases it is the greenstone and not the limestone which is most altered and replaced.

The fact that epidote, amphibole and garnets are developed in the ore is no proof of the contrary, for these contact minerals are developed in all the older rocks—granodiorite among the others, and apparently less readily in the limestone than in the other rocks.

On the south side of Pass creek the solid granodiorite is altered in places to solid garnet. The garnets commence to form in the granitic ^{Garnetized granodiorite.} rock from a number of centres, sometimes with a core of granodiorite as a nucleus, and around these centres develop with crystallographic outlines (M.O.M.), generally distinctly zonal. The growth is continued till all the intervening rock between the centres is converted into garnet. That the material for the formation of garnet and epidote was to some extent at least, brought in by mineralizers and did not depend on the country rock is shown by their occurrence in quartz-filled fissure veins in different rock in this district. The Mother Lode which occurs near a limestone contact, may lie wholly within the limestone. The 'gangue' to a considerable extent is a felt-like aggregate of little actinolite fibres, unlike the usual 'gangue' of these deposits. *Emmons decided, after a microscopic examination, that it is altered limestone. Its contact with the white crystalline limestone is fairly sharp and distinct, but this is not the case in other directions. Ore is found in the crystalline limestone without the green alteration products, but it must be admitted that the ore formation was not always later than that of the contact minerals. That the contacts between lime and other rocks should be favourable may have been due in part to the chemical influence of the lime in precipitating the mineral contents of the solutions, but it was also due to the lack of firm cementing between the limestone and the contact rock, which left free channels that the solutions used as highways and bases for their operations. But while such contacts are favourable, mineralization is by no means confined to them. In fact in the largest deposit yet found in the district (Knob hill-Ironsides), with the exception of an insignificant island of it, found on the intermediate level, limestone is conspicuously absent, although it occurs at numerous unmineralized points in the vicinity. ^{Contacts favour mineralization.}

Ore also occurs in the other Pre-Tertiary rocks; the City of Paris is in serpentine, the Winnipeg in granodiorite and serpentine. Large masses of low-grade sulphides occur in the granodiorite between Brown and Pass creeks. In conformity with the principal structural features the ore deposits oftenest lie about N. and S. with an easterly dip.

The ore bodies
as contact
deposits.

From the foregoing brief description of some of the leading features of these copper deposits it will be seen that they are characterized by irregular and indefinite forms, and by the association of such minerals as garnets, epidote, amphiboles, etc., with sulphides of iron and copper, oxides of iron, with a little molybdenite, arsenopyrite, etc., all of which minerals are primary in the ore. These characters are peculiar to deposits formed by the contact action of eruptive rocks. When an eruptive rock, as a molten mass, forces its way into solid rocks, its effect upon them may be of two kinds. It may cause a re-arrangement of the material of the country rock into characteristic new minerals without altering the chemical nature of the rock. This is largely the effect of heat and therefore is confined to the actual contact between the intrusive and the country rock, being most intense at the contact and gradually fading away from it. A second effect may be to alter the chemical nature of the country rock near and along the contact. This is effected by means of the vapours and liquids the molten rock-magma contains and which are given off when the rock solidifies or reaches the surface. These vapours and liquids are strong mineralizers; they contain chemical reagents derived from the molten rock. This kind of contact action (pneumatolytic) is not as dependent as the former upon the actual contact of the eruptive for its intensity, for the gases and liquids may wander into the country rock along fractures and fissures and do their work there. Consequently, while often found along the actual contact, the 'pneumatolytic contact zone' may be found as islands in the neighbouring country rock. It is to this class of deposits that the low-grade Boundary ores belong.

Somewhat similar deposits, though on a much smaller scale, of magnetite and chalcopyrite occur at * Cherry Bluff, Kamloops lake, near what Dr. Dawson considered a volcanic vent. These have no doubt been formed by volcanic after-actions.

† In the Cristiania district, Norway, magnetite and specular iron, together with the sulphides of copper, zinc, lead, etc., occur within the metamorphosed zone of eruptions, especially of granite, though as far as 2 kilometers from the actual contact. In association with them are contact minerals similar to many in the Boundary district. These deposits are explained by Vogt and others as the result of contact metamorphism and pneumatolytic after-actions.

‡ Lindgrun in a recent paper on the subject of contact deposits gives some United States examples of this same type of deposit.

* Annual Report Geol. Surv. Can., vol. VII. (N.S.), 1894, p. 341a.

† Zeitsch. für Pract. Geology, 1894, pp. 177, 464; 1895, p. 154.

‡ Trans. Am. Inst. Min. Engineers, vol. XXXI. and Genesis of Ore Deposits, 2nd edition, p. 716.

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If these deposits have been formed by contact action they must be connected genetically with some eruptive rock or rocks. At first sight it appears as if the granodiorite might have been responsible for their formation. It outcrops at a number of points, covers a considerable area near the principal ore bodies, sends numerous dykes through the country, and evidently underlies most of the district at no great depth. If it were responsible for the mineralization, ore should not be found in it except in contraction joints near its contacts. Ore, however, is found in it apparently independent of its contact and contraction joints. Moreover, in the Tertiary conglomerates and tuffs overlying the older formations no fragments of ore could be found, although carefully searched for, but they are themselves mineralized to a slight extent. Hence the granodiorite cannot be responsible for these contact deposits.

Relationships
between the
granodiorite
and deposits.

As remarked above, the ore bodies are particularly numerous and large, and have better values around vents, and intrusions of the Tertiary eruptives. The greater number of the smaller bodies are beside and parallel to alkali-syenite porphyry dykes. This is so frequently the case that the relationship can scarcely be accidental. It is true that a large number of these porphyry dykes appear to cut and be nearer than the ore bodies. While this proves that the ores were formed before the close of volcanic activity, it does not prove that they were not formed during the period of Tertiary volcanism. The alkali-syenite magma sent out a number of systems of dykes with a time interval between. On Lower Arrow lake the same magma has given birth to almost a dozen such systems with a sufficient time interval between for the preceding system to cool before the next appeared. Volcanic vents plugged with basic rocks occur between the Knobhill-Ironside and Stenwinder on the west and the Snowshoe on the east. The hill on which Mineral Monument XVIII. stands, near the Emma, Oro Denoro, and not far from the B.C. mine, is another vent similarly plugged. No vent was discovered near Deadwood, but the volcanic flows cover so much of the country in this neighbourhood that the chance for finding one, if it were there, is slim. The tuffs show that there must have been one not far away, and the rocks in this neighbourhood are profoundly altered. It is perhaps worthy of remark that all the large deposits lie immediately under the capping of volcanic lavas, though in some cases these have been entirely removed by erosion. It is reasonable to suppose, therefore, that these deposits and the Tertiary eruptions are genetically connected, and that, therefore, they are of Tertiary age.

Relationship
between the
Tertiary
eruptions and
the deposits.

The ore bodies, like the volcanic rocks, show evidences of movement since their formation: numerous slips, some with gouge or secondary

Movements
subsequent to
ore formation.

filling traverse the ore bodies. This broken nature of the ground, coupled with the original irregularity in the form of the ore body, and the severing of the deposits by dykes, makes the exploitation of the smaller deposits sometimes difficult and precarious. The slips so far encountered have not been sufficiently large to have seriously affected the larger deposits. The serpentine is particularly full of slips, some prior but many subsequent to the formation of the ores, which make it probably the least satisfactory country rock in the district.

A striking feature in the deposits is the lack of surface oxydation or alteration. At most, a few feet below the surface of the ground the ore exhibits the same characters as are found in depth. The soil overlying a deposit is often quite unstained, offering no indication of the underlying ore, and consequently adding to the difficulties of prospecting: sometimes the surface of the ore even retains the glacial polishing.

On the Knobhill the surface of the ore is in places fluted and striated like a mass of Laurentian granite.

Values.

The values in the ores are principally in copper and gold, sometimes with accessory silver. Further study is required to formulate the laws governing the distribution of gold values. Generally magnetite and pyrrhotite when occurring alone are almost barren, yet this is not always the case. In the Knobhill-Ironside the massive magnetite is said to have a gold value. This is said to be the case on the Seattle claim, but in an assay of this magnetite made for the writer no gold was found, though the accompanying chalcopyrite was auriferous. In the Winnipeg mine pure pyrrhotite carries as high gold values as have been found in the mine, but at other points in the same mine barren pyrrhotite is found. Chalcopyrite occurring in magnetite and pyrrhotite is generally a gold carrier, but the gold value of an ore does not always increase with the copper percentage. Thus in the Mother Lode the best gold values are said to be found where the ore runs about 2 per cent. in copper. In the B. C. mine the gold is said to be confined to the chalcopyrite—pyrite and pyrrhotite being barren. On the other hand, in the Brooklyn, Stemwinder and Rawhide the best gold values are reported from the pyrite and specularite ores. So far as could be superficially observed, the local opinion that the intersection of veins or stringers with the main bodies does not cause an enrichment, seems to be supported by the facts. It may be noted that where dykes cross the ore bodies there appears in some cases to be an enrichment of the ore. Possibly there may prove to be a relationship between the quartz and the richness of the ore. Though segregated in places, the chalcopyrite is on the whole remarkably evenly

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distributed through even the immense deposits. In the Knobhill some bodies richer in copper run transversely through the lode. The magnetite is not evenly distributed. In the Knobhill 'Glory-hole,' a band of magnetite 15 feet wide runs parallel to the deposit. In the Ironsides below the Knobhill magnetite is almost wholly absent.

Away from the chief centres of mineralization, while magnetite and pyrite are still found, copper and gold are only sparingly present.

These ores as a rule are of very low grade, lower than was at first hoped. This has been counterbalanced by the size the bodies have shown in development and their remarkable adaptability of the ores to smelting. The magnetite, quartz and calcite are present in the ore in such proportions that, at most, only a little judicious mixing of the ore from different parts of a mine is necessary to produce a self-fluxing product for the smelter. When quartz is a little scarce it can be supplemented by ore from the gold and silver-bearing quartz veins of the district or by silicious ores from Republic camp, across the International Boundary line. Sulphur is so low that no roasting is required. Ten or eleven per cent of coke only is required so that the cost of smelting as well as of mining is exceptionally low.

A member of the Dominion Copper Company kindly granted permission to publish the following figures regarding the contents of the ores of this company, which are more or less representative of the ores of Greenwood camp.

Gross Returns.

Si O ₂	39.00 per cent.	
CaO	17.00 "	
FeO	14.00 "	
Cu	1.95 "	= 39 lbs. Cu (at 10c. per lb.)
Au	119 oz	2 40
Ag	44 oz	0 22

Net Returns.

Cu	83 10
Au	2 40
Ag	0 22
	<hr/>
	85 72

Dr. Ledoux, of the firm Ledoux & Co., New York, through whose hands the output of copper from the district has passed, gives the following information concerning the values of Boundary creek ores.*

* Journal of the Canadian Mining Institute, Vol. v, 1902, p. 174.

The ore from the north side of the Phoenix ravine is estimated to run 1.80 per cent. copper, \$2.40 gold, 25 cents silver per ton. The workable ores from the south side of the Phoenix ravine contain on an average, copper 1.70 per cent, gold \$1.60, silver 33 cents per ton.

The ore from the east side of the volcanic vents (Snowshoe, Gold Drop, &c.) 1.60 per cent copper, \$1.50 gold and 30 cents silver per ton. The run of mines in Greenwood camp as shown by smelter returns is probably 1.60 per cent copper, \$1.80 gold and 50 cents silver. He estimates that the low grade ores of the whole district will run from 25 to 35 lbs. copper, 25 to 40 cents silver and from \$1.50 to \$2.50 gold per ton of 2,000 lbs.

(The B. C. mine near Eholt runs a good deal higher in copper.)

Costs.

The cost of mining is estimated to be from \$1.60 to \$2.10 per ton, the former being the cost more recently. The cost of smelting must be considerably under \$2, and the freedom of the ores from arsenic, antimony and bismuth makes it easy to obtain a market for the copper. The total cost of mining and smelting must be under \$3.60 per ton. Dr. Ledoux's estimates agree pretty closely with the information which has been given us.

Values as high as \$30 per ton are reported on car lots of ore from the Winnipeg mine, and \$20 on shipments from the Humming Bird, the B. C. ore also runs high, but such values are exceptional in the sulphide ore-bodies and the deposits are bunchy and small in comparison with the typical deposits of the district.

Method of mining.

The method of mining adopted is a combination of open quarrying, and the pillar and stope system below ground, similar to that followed in the large iron mines. A description of the method, by Mr. Keffer, was published in the Journal of the Canadian Mining Institute*. The ore in the quarry is usually dropped through an uprise from a tunnel on the level of the ore bins where it is loaded into cars, the large blocks of ore being first reduced by 'bull-dozing' with dynamite or being reduced by an immense crusher.

On the Knobhill the quarrying is to be done in benches, the lower bench being on a level with the railway so that cars may be run in and loaded directly. It is proposed to install steam-shovels for handling the ore, to further reduce the cost of mining.

Permanence of its deposits.

An important question in regard to these deposits is their permanence and character in depth. Unfortunately, it is one that cannot be

* Vol. 5, 1902, p. 213.

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definitely answered. This kind of contact action extends to great depths, and an ore-body formed by it may have a great vertical dimension but in the majority of cases in other districts the mineralization is buncy and irregular and not restricted for a great distance to one plane, though it may be continued along a second plane not far from the first. In the Boundary district the problem is further complicated by the intrusive dykes.

In the B. C. mine below the 400 feet level these become so numerous that it is not worth while following the lead farther, as the proportion of waste rock to be handled would be too great.

The work on the best developed claims, Mother Lode and Knobhill-Ironsidcs shows that these deposits have a considerable vertical extension, and nothing is known of their limit in depth, which may possibly be below the lowest limit for profitably mining such ores. If the plug of brown porphyritic rock east of the Knobhill has vertical walls the ore body with its 45° dip will strike it in depth and cut off this part of the lead. This volcanic plug has not, on the surface a northerly extension, so that it is probable good ground will lie between it and the volcanic plug which lies just north-west of Phoenix station.

Extent of ore bodies.

The smaller deposits are generally buncy though often a number of ore masses lie within a small area.

The character of the ores may be expected to remain unchanged, although possibly sulphur may become a little more prominent. Since these deposits show no surface alterations the values are not likely to lessen while the other conditions remain unchanged.

If, as there is good reason for believing, these deposits are of approximately the same age as the Tertiary eruptives, then it is almost the original surfaces of deposits that are at present exposed and being worked, for as they are immediately under the volcanic rocks, very little of the deposits can as yet have been eroded. It will be interesting to see, if with depth, they do not contract, with perhaps a concentration of values.

DESCRIPTION OF THE MINES.

It is impossible within the limits of the present report to give a detailed description of each mine. That will be done in the final report, but a few notes on some of the principal mines will be given here to add definiteness to the above general description of the low grade copper ores of the district.

Knobhill Ironsidcs mine.

Greenwood or Phoenix Camp.

Knobhill-Ironside Mines.—The Granby Consolidated Mining, Smelting and Power Co., Ltd., own and operate these mines. The following claims owned by the company lie in and south of the Phoenix ravine: Phoenix, Fourth of July, Old Ironsides, Knobhill, Victoria Ætna, Gray Eagle, Banner, Tip Top and Triangle Fraction.

The ore deposit as developed lies about magnetic N. and S. running through the Old Ironsides, Knobhill and into the Gray Eagle. Its dip is 45° thus carrying it under the Victoria and Ætna claims.

Nature of
country rock.

The country rock is principally the old green volcanic breccia with bands of tuffs and ash, locally known as diorite. The fragments are of chert, argillite, porphyrite and limestone with a few of granite. A little limestone is encountered at the north end of the intermediate level of the Old Ironsides. A dyke of the gray granitic diorite-porphyrity may form part of the 'gangue,' but it is too much altered to be identified with certainty. But it is found on the north side of the ravine and the structure of some of the altered rock, forming the gangue, resembles that of the diorite-porphyrity. On the Knobhill spur, a little east of the ore bins, and forming the foundation of the new compressor plant, is a white granular, even-grained Tertiary tuff, consisting largely of quartz and feldspar fragments of uniform size. It is locally known as 'porphyry.' It occurs interbanded with beautifully laminated cherty ash beds. This rock extends south-westward up the hill to the Gray Eagle, but is pierced by a somewhat circular plug of brown porphyritic rock which might be called basalt. The white tuff at the contact has been melted to a glass for a fraction of an inch, and the rock of the plug has a less highly crystalline selvage which resembles the reddish alkali porphyries. This is no doubt the filling of a local volcanic vent. On the higher ground to the east, dark grayish or purplish andesitic lavas form a capping over the tuff and Pre-Tertiary rocks. These lavas extend across the railway at the station, but are there pierced by a second volcanic vent plugged with a rock similar to the first. Grayish, reddish and pinkish alkali syenite porphyry dykes are common in the neighbourhood, but the only dyke seen in contact with the ore was at the north end of the lead. The western limit of the ore body is well defined but the eastern has not yet been determined, nor has its extension in other directions been definitely established although the development work done on the property no doubt exceeds three miles. (On March 21, 1902, it was calculated to be 14,771 lineal feet.) The material mined consists of magnetite, chalcopyrite, pyrite, specularite, pyrrhotite, calcite, quartz, garnets, epi-

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dote and hornblende together with less highly altered country rock. In the Knobhill quarry or 'Glory hole' magnetite is concentrated in a band at least 15 feet wide, through which the copper and iron pyrites are scattered. The band runs parallel to the lead. On the Ironsides the ore is mixed with a great deal of calcite, and magnetite fails. It seems as if the calcite and magnetite alternate with each other in these ores.

The ores from the different parts of the mines are sorted into three bins as :—I. Ordinary ore-rock—garnet, calcite, hornblende, magnetite, copper and iron pyrites. II. Calcareous ore—rich in calcite and poor in magnetite. III. Ferruginous ore, rich in magnetite. No. III. comes largely from the Knobhill and II from the Ironsides.

East toward the Victoria shaft, where the ground was being stripped by ploughs, scrapers and aerial carriers, the ore uncovered contained a good deal of quartz. At one place the silicious band was separated from the ordinary ore by what appears to be a slip. The equipment and method of mining are described in the report of the Minister of Mines for British Columbia, 1901.* A 60-drill compressor, and two 700 h. p. electric motors are being added to the plant. The output from the big quarries and immense stopes is limited only by the smelter's capacity.

Brooklyn-Stemwinder Mines.—These properties, lying on the north side of the Phenix ravine, belong to the Dominion Copper Company. They have had a considerable amount of work done on them, but have been closed down the past year. The country rock is the old green pyroclastic, containing a great many fragments of limestone, with some of quartz, porphyrite and ash material interbanded with limestone.

Brooklyn-Stemwinder mines.

A dyke of diorite-porphyrity occurs to the west, and many pink alkali porphyry dykes occur in and near the ore bodies. The ore is altered rock containing chalcopryrite, pyrite and specularite. In the Brooklyn, the ore body, which is about 25 feet wide, occurs along, but not in the limestone, which seems to form a containing wall for the ore. This is the statement of the late manager and it agrees with what we saw in the field and in microscopic slides. In the Stemwinder, three courses of ore are supposed to occur. While development work has revealed large bodies of ore, apparently not enough has been blocked out to warrant the erection of a smelter, and the tariff for custom smelting is a great tax on those low grade ores.

* For particulars as to development and equipment of the mines consult the Reports of the Minister of Mines for B. C.

Snowshoe
mine.

Snowshoe.—Owned and operated by the Snowshoe Gold and Copper Mines, Ltd.

The conditions here are somewhat similar to those obtaining at the Knobhill-Ironsidcs, except that the ore-body as explored is smaller though still of immense size. The country rock is the old green volcanic conglomerate or tuff, whose character is distinctly recognizable where not too much altered by mineralization. A lens of gravel-holding crystalline limestone occurs along the west side of the ore-body. A little above it on the Gold Drop, the capping of lavas mentioned above in describing the Knobhill, is exposed. Some dykes of porphyry and dark lampophyres cut the older rocks. Although 7,000 feet of development work has been done, besides a good deal of diamond drilling, more will be necessary before very definite statements can be made regarding the form of the deposit or deposits. The contour of the surface of the claim seems to conform roughly to that of the deposit, but the latter is more undulating. The ore along its western boundary is dipping eastward, and on its southern boundary it is pitching northward. At its north end at the old shaft the dip is southerly, so that it would appear to form a rude basin. There appears to be a second parallel ore-body. The determination of the form and limits of ore is complicated by the numerous slips, some with much gouge showing that there has been a good deal of movement since ore deposition. Some of these appear to have brought unmineralized rock against ore. The mineralization itself is not regular, horses of rock appearing in the ore. The ore consists of chalcOPYrite, magnetite, specular hematite, pyrite, quartz and calcite with some epidote, garnet and serpentinous material. The minerals of the ore are not evenly distributed. Magnetite often occurs in bunches, some parts of the ore are highly silicious and others very calcareous. At the outskirts of the ore-body, as at the south end, stringers of calcite with bunches of ore, sometimes solid chalcOPYrite, follow fissures in the rock. The values occur principally in the chalcOPYrite; magnetite bears a little gold and silver, while the hematite and pyrite are almost barren. No pyrrhotite or arsenopyrite has been found.

The method of mining is the same as that adopted in the other large properties. The high pressure half, of a 30-drill compressor is being installed to supplement the 5 and 7 drill compressors already in use. Two 80 horse power boilers are being put in, in addition to the 70 horse power boiler already at the mine.

Deadwood Camp.

Mother Lode
mine.

Mother Lode Mine.—Owned by the British Columbia Copper Co., Ltd. The group of claims include the Mother Lode, Primrose, Off-

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spring, Tenbroek, Don Julis and Sunflower. Mining has been confined to the Mother Lode, but it ranks next the Knobhill-Ironside as the largest and best developed property in the district. In many respects the deposit resembles the other large ore bodies but it has several features of its own. As in the majority of cases its strike is nearly north or south (a little east of north), and its dip is eastward 55 to 70°. It outcrops at intervals for about 2,000 feet, but is only developed north of the shaft, located about the centre of the deposit. Where explored, its width averages perhaps 140 feet, but its boundaries are somewhat indefinite. The ore is continuous to the 300 feet level, the deepest workings, which are some 500 feet below the highest outcrop of the deposit. More than one ore shoot occurs. On the 300 feet level two are well defined. The minerals occurring in the ore are magnetite, chalcopyrite, pyrite, with a very little zincblende, galena, pyrrhotite and an occasional trace of arsenopyrite, calcite, actinolite, garnet, epidote and quartz. (The ore and rocks of the Mother Lode have not yet been studied microscopically and cannot be described definitely). No specular hematite has been found. The ore like that of Phenix camp is divided into three classes:

I. Silicious, made up of the various silicates of calcium, magnesium, aluminum and iron with massive and disseminated copper and iron pyrites, and a little zincblende.

II. Calcareous calcite and quartz with copper and iron pyrites, sometimes massive, sometimes finely disseminated. Near the wall in the 200 feet level, this ore has some argentiferous galena and blende.

III. Ferruginous ore, consisting of fine-grained magnetite with quartz and chalcopyrite.

These three classes of ore often occur separately but are sometimes mixed. A large mass of magnetite occurs at the entrance of the mule tunnel and several bands of it occur in the west side of the deposit, apparently dipping west. The silicious ore often differs from the Phenix ores in the amount of fibrous actinolite it contains, and the ores as a whole contain more magnetite. They also differ in not carrying hematite.

The three classes of ore are said to have the composition given in the following partial analysis*.

	I. Silicious.	II. Calcareous.	III. Ferruginous.
Silica	44.23	20.10	27.33
Alumina	7.46	1.31	....
Iron oxyde	16.83	12.00	51.12
Lime & magnesia..	16.03	34.00	10.26
	84.55	67.41	89.71

*British Columbia Mining Record, May, 1902, p. 173.

The silicious ores carry a little silver as well as gold and copper. The blende and galena are argentiferous. Magnetite and pyrite, as a rule are not auriferous, but in the Keffer stope the magnetite carries gold. The chalcopryite when present in such quantities that the ore runs 2 per cent copper, seems to be the best gold carrier, but when nearly pure running 30 per cent copper it carries no gold. The ore along the porphyry dyke carries rather better values than elsewhere. The rock on the west of the ore body forming the foot wall, is an apparently very pure white crystalline limestone. It dips south and east, bending round and cutting off the ore at the north. It has been encountered on the 200 feet level but has not yet been found on the 300 feet. The rock on the east is a green fissile epidote-like material that is said to have the same chemical composition as the ore, except that the metallic minerals fail. Across the ravine to the south the rock appears to be argillite. To the north of the lead the rock is greenstone-tuff and conglomerate, and these greenstones appear to surround the mass of limestone which has no great dimensions. All these rocks, especially to the north, are heavily dyked by the pink alkali-syenite porphyries, and on the surrounding heights, and occasionally in little basins on the slopes, the Tertiary lavas are found. A heavy dyke and one or two smaller ones, of alkali porphyry run through the ore body nearly at right angles, lying almost horizontal but with a low dip to the south and west.

The limestone contact is generally somewhat sharply defined, but it shows a little irregular alteration and some of the metallic minerals occur sparingly in the pure crystalline limestone along the contact. The rock to the east is too much altered to be identified with the unaided eye, but it is likely to prove to be altered argillite. It is likely that the western part of the ore is altered limestone, while the eastern may be altered argillite. No limestone is found in the ore body. It may be stated that the lime in the ore always occurs either combined in the silicates or as calcite scattered through the ore like the other constituents. At the north end of the deposit the altered epidote-like rock overlies ore on the surface and has to be stripped off before quarrying can be done. Recent stripping at this north end has revealed a fine body of good grade ore.

On the lowest level the ore body seems to be altering its dip as if to become parallel to the porphyry dyke. But further work is necessary here before the shape of the ore body can be intelligently discussed.

Sunset mine. *Sunset Mine.*—The Montreal and Boston Copper Co., Ltd., owns this claim together with the Crown Silver, lying between the Sunset and Mother Lode, the C. O. D. and Florence fraction. A two-compartment

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ment shaft has been sunk on the Sunset and one shaft 260 feet deep on the Crown Silver, and considerable work done, especially on the Sunset (in the neighbourhood of 5,000 feet). The ore body above the 100 feet level has been opened up ready for stoping. It has a width of 115 feet and it is estimated there are 250,000 tons of ore ready to be taken out. Only a few special features in connection with this mine will be mentioned.

On the foot wall the rock is altered to almost pure silica. It appears to have been either the greenstone tuff or argillite. In places it is brecciated; the pebble-like fragments are embedded in serpentinous matrix. Going into the tunnel from the S. E. on the 100-foot level, after a few feet of silicified and slightly pyritized rock, a heavy slip is encountered which runs N. and S., angle about 50° W., and west of this is solid magnetite ore with some pyrite or chalcopyrite scattered through it. Sometimes the ore is banded. A solid band of pyrite at least 4 feet wide occurs separated from the ordinary ore by two feet of crushed country rock.

The magnetite sometimes occurs in rosette-like aggregates resembling hematite. Quartz occurs as blebs through the ore, calcite is scattered through and occurs as stringers. Actinolite and epidote sometimes occur in the magnetite. The lower levels were not examined as the mine was closed down at time of our visit owing to the strike of coal miners at Fernie. A specimen of marcasite was shown me, said to occur in a vein cut on a drift from the 300 feet level, running towards the Crown Silver. It is said to run 830 a ton in gold. An ore shoot of sulphides several feet wide with good gold values is said to occur on the 200 and 300 feet levels, which will be used to increase the grade of the 'run of mine.' Alkali porphyry dykes are found running through the ore body, but they are usually small and have no apparent effect on the ore. They have a distinct salband, but their walls are sometimes slickensided, showing that the country rock has moved along them since their formation.

Here, as elsewhere, the ore body shows the effects of earth movements since the ore was formed.

Summit Camp.

B.C. Mine.—This mine is owned by the B. C. Chartered Company, B. C. mine. Ltd., which also owns a number of claims in the vicinity.

This mine possesses peculiarities which deserve noting. The ore body occurs on a contact between white crystalline limestone

and greenstone, too much altered to determine whether porphyritic or pyroclastic. In thin sections the porphyrite structure can be seen, but this might be a fragment, and north along the wagon road to Eholt, a short distance from the mine, the tufaceous character of the rock is distinct. South, in the south-west corner of the basin in which the mine lies, the compact porphyrite occurs. Dykes of diorite porphyrite, somewhat the worse for wear, occur in these rocks, one just west of the dining-hall. The exact form and extent of the limestone mass cannot be made out, partly owing to covering of drift and partly owing to the alteration which it has sometime undergone.

It appears to be a lenticular mass lying north and south in the greenstone, extending from about the railway spur north of the shaft house, to a point on the hill-side, 200 paces south of the south prospect shaft.

Main ore
body.

A large mass of limestone occurs on the hill at the head of the basin, and along the ridge between the B. C. and Rathmullen creeks. Toward the north end of this ridge are greenstone tufts and conglomerates, extending westward across B. C. creek. These are capped by Tertiary lavas and sheets of alkali porphyry and are much cut up by dykes and intrusive sheets of the latter rock. The main ore body of the B. C. is a lenticular mass, lying about north and south, with a slight easterly dip. It is 65 feet wide and about 200 feet long, but contracting along both dimensions as it goes downward. It is very much cut up by intrusive sheets of alkali porphyry which form regular floors in the lode. There are two sets of these sheets, one a coarser grained reddish porphyry with biotite crystals in addition to numerous feldspar crystals, and a later, light pinkish set, with no visible crystals except those of feldspar. Both sets have distinct salbands against the ore, but the ore does not appear to be affected by them, being continuous from one sheet to the next one below and so on down. It has, however, a platy jointing parallel to the sheets, along which the ore falls readily away. This plating may be due to heating by the dykes and subsequent contraction.

Depth of
mine.

The ore is mined to 400 feet, below which the sheets become so heavy and numerous that it would not pay to extract the ore. Other ore shoots on the lead are being tested by surface workings. Sufficient ore has already been taken out to have made the mine a success.

Several diamond drill holes have been run from the 400 feet level, one to a depth of 511 feet below. While a considerable amount of ore was gone through, even to the bottom of the hole, a large proportion

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of the core was of alkali porphyry. Toward the bottom of the hole a good deal of granodiorite was cut through, as though this rock occurred *en masse* at no great depth below.

The ore consists of chalcopyrite, pyrrhotite and a little pyrite, with the following gangue minerals—garnet, quartz, calcite, and magnesium carbonate, epidote, zoisite, actinolite, chlorite, serpentine plagioclase, and probably kaolin. Nature of ore.

This gangue is in part at least altered greenstone, as the structure was retained in a microscope slide. As the limestone, though rather sharply defined, shows some alteration and garnetization, it may form part of the gangue. Garnet is probably the most abundant gangue mineral.

A little specular hematite and zincblends occur on the outskirts of this ore body. The walls are merely "commercial walls."

A fault parallel to the ore body runs through porphyry and ore with no great vertical displacement.

About 200 feet south of shaft house an open cut shows a contact of the white crystalline limestone and the altered garnetiferous rock. The division between the two is sharply defined.

The values are considerably above the average for the Boundary district, principally in copper. The average assay for the ore shipments to the end of 1901 is said to be: copper, 5.8 %; silver, 2.45 oz.; gold, .015 oz. The best values have been obtained when the ore body is constricted.

In addition to the mines described, considerable work has been done on a great number of properties, in some cases with encouraging results. Other claims.
In Deadwood camp might be mentioned—Morrison, Marguerite, Greyhound, Ah There, Buckhorn; in Phoenix camp—Gold Drop, Rawhide, Idaho, War Eagle; in Wellington camp—Golden Eagle, Winnipeg. Athalston; in Summit camp—Emma, Oro Denoro.

Sulphide deposits, sometimes of considerable size, also occur outside the areas described, as between Brown and Pass creeks, also eastward to the North Fork. These have never advanced beyond the prospect stage, either on account of the grade being too low, or where the grade is satisfactory, on account of the ore being bunchy or through lack of capital. It is possible that valuable deposits will yet be opened up in these parts of the district. Southward and eastward from the main

centre of mineralization, these deposits seem to gradually lose their distinctive character and grade into sulphide-bearing quartz veins, often with well crystallized garnets and epidote in the quartz. Most deposits of this class are as yet merely prospects.

Some of the deposits in Central camp may belong here. The City of Paris is the most prominent property in this locality.

City of Paris mine.

The rocks in this camp are black argillites with intercalated lamellae of quartz, large masses of serpentine intrusive in the argillites, and dykes and bosses of diorite-porphyrity. Cutting these rocks are more recent porphyry and lamprophyric dykes. The rocks are much shattered and altered. The mine is on a steep side-hill. A tunnel about 1,000 feet long has been run in to the lead, from which drifts run N.W. and S.E., along the lead. These are connected with two shafts to the surface. The rock at the entrance of this tunnel and for several hundred feet in, is an altered gray porphyry rock, probably altered granite-porphyrity or diorite-porphyrity. Its general dip and the dip of its joints is about N.E. Joints or slips in it are filled with little stringers of quartz and calcite. Beyond this altered porphyry is serpentine, very much dissected by slips and fractures.

The lead runs about N. 22° W., and varies in width from mere stringers of ore to 15 feet.

Cross cuts.

From the north-west drift along the lead four cross cuts have been run 90 feet. The rock traversed by them is impregnated with and traversed by stringers of quartz and calcite carrying sulphides, which diminish in amount with the distance from the main lead. In one cross cut an ore body was encountered running S.W., or diagonally to the main lead. The ore occurs in chutes. A dark dyke occurs in the mine with ore following it on each side.

The ore on the north-west drift consisted of argentiferous galena, blende, tetrahedrite, chalcopyrite and pyrite, while on the south-east drift the ore is almost massive pyrite and chalcopyrite. The ore from the north end of this mine was sent to the lead smelter at Trail, that from the south to the Granby smelter at Grand Forks.

Values.

The values are said to be unevenly distributed, running in pay streaks. The tetrahedrite gave very high assays. The mine has been idle for the last year and a half, pending, it is said, increased transportation facilities.

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II. Oxydized Copper Veins.

These are found in Copper camp at the head of Copper creek. They occur in the Pre-Tertiary rocks along the lower border of the Tertiary lavas, which in thick sheets lie as a capping over the older rocks. ^{Oxydized, copper veins.}

A short description of the King Solomon claim will illustrate this type. This deposit is met with at a contact between a dyke of alkali porphyry and crystalline limestone. Wedge-shaped tongues of the porphyry extend from the main dyke into the limestone. Both the limestone and the dyke are much fractured and traversed by little slips. These fractures cut the limestone into small blocks. In the limestone, and to a less extent in the fractures in the porphyry, along the contact, are deposited various oxydation minerals of iron and copper, including native copper. These embrace red massive and earthy hematite and yellow limonite, crystallized and massive malachite and azurite, a black amorphous substance, containing copper oxide (melanconite), lampadite and chalcocite, cuprite, often in transparent crystals, native copper, chrysocolla and probably copper-pitchblende. The edges of the small limestone blocks have often been dissolved and the copper ores then occur as incrustations surrounding a core of lime. The main fissures are filled with the iron and copper minerals, the smaller principally with the copper. In the porphyry it is only the fractures near the contact which contain a thin film of copper ore, the rock itself remaining fresh and unaltered. About 650 feet from the main working on the King Solomon is a small vein. The rock is here not so badly shattered. On the surface, carbonates and other copper minerals with iron oxides are found; a little below the surface the sulphates of these metals occur, and below these unoxydized pyrite and chalcopyrite begin to appear. What can be seen to be taking place here on a small scale is probably what occurred on the King Solomon ledge (proper) on a much larger scale, so that this type of deposit is probably an oxydized and secondary enriched form produced by the action of surface waters of a sulphite deposit, similar to the first type of Boundary deposits. The iron of the sulphides has been removed or redeposited as hematite and limonite; the copper has been more or less concentrated in the form of various oxydized minerals. ^{King Solomon claim.}

The Big Copper claim, a little to the north of the King Solomon, on which some work was done this summer, affords additional information regarding this type of deposit. ^{Big Copper claim.}

An open cut was run in on the lead 88 feet. The course is about 311° at first but bends round to about 264° (astronomically). The dip

is N. at a high angle. The foot wall is crystalline limestone of convex form, which constricts the vein from a width of 20 ft. at the top of the cut to a width of 6 or 7 feet at the floor. The hanging wall contains some garnet and may be altered greenstone tuff, but it is too decomposed for identification. A dyke of porphyry similar to the King Solomon occurs in the hanging wall. The limestone near the vein looks like an agglomerate with a green matrix containing quartz and other material in pebble-like particles. The matrix is mineralized to some extent, but the limestone is not. Until this is studied, it cannot be affirmed that this matrix is not an alteration of limestone along fractures.

The surface of the vein is altered to a red earthy hematite, which paints everything around; below this is chalcocite in masses a foot square; this can be seen giving place to bornite and the latter to chalcopyrite. Specimens can be gathered showing a nucleus of chalcopyrite surrounded by a zone of bornite, and a periphery of chalcocite. A little native copper and cuprite carbonates occur near the surface. Evidently surface waters have leached out copper on the surface of the deposits and this descending on the vein, and coming in contact with the iron-bearing chalcopyrite, the copper they contained has been precipitated or has replaced the iron of the pyrite, thus enriching the ore finally to chalcocite, after the manner already described by Emmons and Weed.*

The best grade ore is found in the vein overlying the limestone. The ore is said to run 15 per cent in copper, and to carry 84 in gold and 9 oz. in silver per ton. The hematite extends up the hill to the base of the lavas. The depth to which the vein is oxydized and the value below this zone can only be determined by additional work on the deposit.

Copper camp
zone of
oxydation.

That a zone of oxydation and enrichment should be found in the veins of Copper camp and not elsewhere in the district may in part be explained by the local topography, and the broken nature of the country rock, but the chief factor, in all probability, has been the capping of the volcanic rocks which covers the hill-tops all around and extends almost to the King Solomon and other of these deposits, the deposits occurring underneath their lee. In pre-glacial times these rocks are likely to have extended a little farther, in which case they would have protected the deposits from the scouring effects of the ice-sheet. In addition, the contact between the volcanic and older rocks is likely to be a natural waterway.

* Genesis of Ore Deposits, 2nd edition, Am. Inst. Min. Engineers, page 433. Trans. Am. Inst. Min. Engineers, vol. XXX. Bull. Geol. Soc. Am., vol. IX., 1900, page 179-206

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The basalts lying above these deposits carefully tested by Mr. Macneil of the School of Mining, Kingston, have been found to contain no trace of copper.

III. Gold and Silver Veins.

These are found on the outskirts, or between the areas in which the large low grade deposits occur. They are found filling fissures and replacing the country rock along fissures. In their relationship to the rocks of the district they are similar to the deposits of the type I. There is nothing to show that they are not of the same (Tertiary) age. The gangue is generally quartz with some calcite, and in one or two veins near Hardy mountain, siderite.

The economic minerals are chalcopyrite, pyrite, galena, blende, tetrahedrite; sometimes rich silver minerals as ruby silver, argentite, native silver, with in some cases tellurides and native gold. The veins vary in width from a few inches to several feet. To illustrate this type of deposit three of the best developed veins will be briefly described:—

Economic
minerals.

Jewel Mine.—Situated in Long Lake camp, about eight miles from Greenwood and four miles from Eholt.

The mine is upon a contact between the gray biotite-hornblende granodiorite and a green schist, which, however, is generally dark green in this vein through development of biotite. As it has not been studied microscopically its original nature is still in doubt. The granodiorite is developed extensively to the south and west, the schists extend northward and across Long lake, but are very heavily cut by alkali porphyry dykes, which, on Roderick Dhu mountain, form the principal rocks. Dykes of this porphyry occur in the mine as well as small dark lamprophyric dykes.

Situation of
Jewel mine.

The vein runs about N. and S., with a dip of about 45° E. (The Jewel shaft has a dip of 39° 30' east). For the most part, as at present developed, granodiorite forms the foot wall and schist the hanging, that is, the ore occurs along the contact, but on the south it is in the granite alone, and it is sometimes found in the schist. The granite contact is not altogether regular, as tongues of it run into the schist. The vein varies in width from 2 to 12 feet with an average width of say 4 feet. Horses of country rock occur in it, often filled with ramifying veinlets and blebs of quartz, so that there has been replacement as well as fissure-filling. The vein is considerably cut up by the porphyry and lamprophyric dykes. A large dyke of porphyry which is

Dykes.

exposed on the surface at the engine house, runs E. and W. and dips north at an angle of about 50° . It is also encountered in the 120' and 230' levels. It seems to cut the ore. In the south extension of the 230' level it has a salband against the ore, but the sulphides are in contact with it and some quartz blebs occur in the porphyry. The ore at this point becomes disseminated in numerous stringers through the rock, which is mineralized for a width of 30 feet. There appears to be a heavy fault here, as the ground is much broken up and a tongue of the massive granodiorite is reduced to a gravel-like mass. The long tunnel to the north is in ground full of slips, with stringers and bunches of quartz running in all directions. This is in schist, a little to the east of the granodiorite contact. It may be that the compact granitic rock has had a mechanical effect in concentrating mineralization, whereas the mineralizers were more disseminated through the schist. One dyke 4 feet thick occurs a few feet below the 120' level, dipping 30° to the west. It throws the ore 8 to 10 feet east—a normal fault. A lamprophyric dyke encountered north of the shaft dips southward. It crosses the 230' level north of the shaft and the 300' south of it. It appears to have affected the ore, rolling it back on the 230' level. There are numerous small lamprophyric dykes, some only an inch or so wide, running continuously from level to level. These dykes cut the ore and are therefore later. The larger ones fault the ore, generally to the east, in normal faults. Faults later than these dykes have also affected the ore body. Some are parallel to the ore and form a secondary wall, with gouge. That these are not original walls is proved by their faulting the later dykes. Unless the faulting has brought up unmineralized country rock, ore may therefore be found outside them.

Such a relationship between ore, dyke, fault and secondary wall can be seen in the stope south of what is known as the 'extension.'

In one instance, along the footwall, the vein has been brecciated by movement, forming a band 8 inches wide of rounded and angular fragments of quartz in a greenish white matrix, separated from the solid ore by gouge. It is altogether probable that there has been considerable replacement as well as fissure filling. The granitic rock, as well as the schist, has little veinlets in it near the ore body. Following the vein northward along the surface a heavy dyke of porphyry, perhaps 300 feet wide, is encountered, which runs E. and W. It appears to fault the vein considerably, as ore is found on the north side 275 feet to the east. On this vein about 1,000 feet from the main shaft, in a direction 10° E. of north, is a second shaft, down 150 feet, known as the Rowe shaft. The shaft is inclined $53^{\circ} 30'$ eastward, and follows

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the vein to between the 100 and 150' level, when a porphyry sheet cuts through. It appears to fault the vein, as on the 150 feet level, a drift a few feet long had to be run east to catch the vein. A quartz vein is found on the Enterprise, Ethopia and other claims to the north, which appears to be the northward extension to the Jewel vein. The ore is quartz, containing galena, pyrite and chalcopyrite. In the upper part of the vein some free gold and rich tellurides are found. The amount of sulphides and the values vary greatly from place to place in the vein, and no rule governing the distribution has as yet been discovered.

The walls are mineralized for a short distance from the vein, the hanging wall as a rule having better values than the foot, running of ore. Gold contents from 81 to 83 a ton for two feet or so from the vein. The galena carries the best values; pyrite is also rich. Chalcopyrite is likewise valuable, but there is very little of it in the ore. Solid galena is said to have assayed \$300 in gold per ton. Solid pyrite assayed \$57 in gold. Some silver is also present. The ore as mined is said to run from ten to twelve dollars per ton. If a method of successfully concentrating the ore can be secured the future of the mine should be bright. Some calcite in veinlets occurs in the ore and in fractures in the dykes, so that it is probably of later formation than the vein. A mineral which appears to be sericite is developed in the quartz to a limited extent, and the formation of mica in the schist seems to be the result of the agents of mineralization.

Providence Mine.—Situated one mile north of the town of Green- Providence wood. Though one of the first claims located, and though 45 tons of ore shipped by pack train in the early days netted a handsome profit, very little work has been done on the property. The reason seems to have been that the vein, after following the shaft for a distance, began to dip away from it at a considerable angle. This discouraged the operators and about the same time quartz veins went more or less out of fashion in the district, the low grade deposits receiving the attention. Recently Mr. Fowler, a prospector, took over the claim, followed the vein where it dipped out of the shaft, and now the prospect gives promise of becoming a profitable little mine. The rock is greenstone or greenstone tuff, along a contact with granodiorite: the vein, however, so far as developed, is in the greenstone. At the entrance to the open-cut the granodiorite is exposed. Next follows a 10' east and west dyke of porphyry and then the greenstone. The vein seems to bend eastward along the north side of the porphyry dyke. The vein in the open cut strikes 21° (mag.), dipping 60° to the east. At and between the two shafts its course is 40° (mag.) The dip is 60° south-east. About 10' below the surface in the shaft the vein pinches and

flattens for a short distance, when it pitches down and widens once more. Its width varies from 8 inches to 4 feet, with an average width of rather more than one foot. The vein then is not uniform in direction, dip or width. Some slips occur, faulting the vein a foot or 15 inches eastward.

Description
of ore.

There is some replacement of the wall rock, the greenstone being silicified and pyritized, and traversed by tiny veinlets. The ore is white, rather watery quartz, often crystallized or with a tendency to crystallize, containing calcite, galena, zinc blende, pyrite, chalcopyrite, with some tetrahedrite, chalcocite, ruby silver and argentite, native silver and gold. A little sericite seems to be developed in the quartz. The galena occurs in masses an inch or more in diameter, with zinc blende. Tetrahedrite is found through the galena and the quartz. Chalcopyrite occurs in this quartz in particles up to $\frac{1}{2}$ inch in diameter. The chalcocite, the rich silver minerals and the native silver and gold occur generally in films around quartz crystals or in small crevices and cracks through the quartz or in the small masses of gray calcite contained in the quartz. This occurrence of rich minerals in films in secondary cracks in the ore shows that there has been secondary enrichment, and that both silver and gold have been carried in solution and precipitated. This work has probably been done by surface waters. Not enough work has been done to determine the depth to which this enrichment extends.

The galena and tetrahedrite are both very rich in silver and have good gold values.

The 45 tons shipped in the early days to the Tacoma smelter are said to have yielded 200 oz. of silver and $6\frac{3}{4}$ oz. of gold per ton.

Since work has been resumed shipments have been made which have also yielded high returns. A shipment in August ran about \$145 per ton.

Not enough work has been done to show the relationship between the vein and the porphyry dyke. As stated above, where exposed the vein bends east along the porphyry. If the porphyry does not cut the vein, the latter is almost certainly of Tertiary age.

No. 7 Mine.—Owned by the No. 7 Mining Co., Ltd., of New York, situated in White's or Central camp.

The vein occurs on a contact between serpentine on the west and black argillites on the east, and on both sides are light and dark porphyritic dykes.

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The vein which varies from 18 inches to 7 feet in width, runs N. W. by W. It dips 53° E. to the 60 feet level and then flattens to 45° . On the footwall and forming a wall to the vein are several small black dykes, too decomposed for determination, and these are of great assistance in mining. In the hanging wall is a dyke of gray syenite porphyry. In the prospect tunnel 250 feet east of the shaft house this cuts the vein and faults it with a throw of 5 feet. On the 60 feet level it also cut the ore and a tongue of it divides the vein into two branches. A second dyke of apparently the same rock cuts through it and everything else. The course of this second dyke is S. E; dip about 50° S. W. A dark micaceous dyke 20 feet wide also cuts the vein. The vein is occasionally found completely in the serpentine. The ore is quartz, carrying galena, a little blende, a little pyrite (possibly marcasite) chalcoppyrite and tetrahedrite. The ore is often banded. On the 200 feet level, east drift, the ore has some bands of country rock lying in it, so that replacement has occurred here also. The galena carries silver values and the pyrite gold values. The ore assays from \$7 to \$60. As shipped it runs probably from \$10 to \$15.

The mine has been developed to the 300 feet level. In July shipment and work was suspended on account of the difficulty of transportation.

Quartz veins are numerous in the vicinity of Greenwood and between July creek and the North Fork of Kettle river. They occur in all the Pre-Tertiary rocks. With typical fissure veins replacement of the country rock is generally somewhat pronounced. Some of them have been developed with satisfactory results, some are too poor to work, while others seem to have lost values below a shallow zone of secondary enrichment. In general they have not received the attention that might have been expected or that they deserved.

*Other materials of economic or possible economic importance
in the district.*

Platinum.—In the report of last year the writer called attention to the possibility of platinum being found in the district and neighbouring parts of British Columbia. The reasons for expecting platinum in this part of British Columbia are:—1. The widespread occurrence of basic eruptive rocks, now mostly altered to serpentine. It is in such rocks that platinum has been most frequently found, and so far as is known, the platinum of placers has been for the most part derived. 2. The similarity in the geological conditions here and in the Similkameen district, where the most productive platinum placers in North America are located. 3.

The resemblance between the chalcopyrite-pyrrhotite ores of this part of British Columbia and those of the Sudbury district, where those ores carry sperrylite, the arsenide of platinum. It has recently been reported as occurring in the copper ore of the Rambler mine 60 miles from Laramie, Wyoming. In a *Bulletin on Platinum by J. F. Kemp, just issued, the author gives the results of his investigations on the occurrence of platinum in the Similkameen. He found platinum to occur in quantities varying from traces to nearly 2 oz. per ton in serpentine bands in altered peridotite. It was also detected in dykes of pyroxenite in the peridotite, and probably as a secondary mineral in an altered granite.

During the past summer platinum was found in Burnt Basin, about 15 miles east of the present sheet, in a gold-bearing quartz vein, on the Mother Lode claim belonging to the Contact Consolidated Mines, Ltd. Samples of the ore were sent by the manager, Mr. Henry P. Jackson, of Rossland, to Baker & Co., Newark, N. J., for assays. These yielded results varying from traces to 0.25 oz. per ton. In a sample of Mother Lode ore brought in by the writer and assayed by Mr. Manly Baker, of the School of Mining, Kingston, platinum was obtained but not weighed. In similar samples, Mr. D. Locke of this department obtained results varying from traces to 0.1 oz. per ton. The quartz carries free gold, near the surface at least, and chalcopyrite, pyrite, galena, blende and molybdenite. It occurs in dark schistose rock which is probably altered porphyrite cut by syenite porphyry dykes, and a basic syenitic or gabbroitic rock. Nearby are limestones and gray granite. Veins of galena and blende occur in the limestone in the vicinity.

Tin.

Tin.—Is reported to have been found near Long lake, but no information could be obtained regarding the exact locality. It is quite possible that traces may occur in connection with the intrusions of granitic rock in that part of the district. But no alterations of these rocks were observed, such as take place where tin occurs in commercial quantities.

Coal.

Coal.—In the elastic and pyroclastic rocks of Tertiary age, underlying the volcanics some small lenses or bands of coal are found. West of Midway, outside the sheet, a bed is of sufficient thickness to have attracted attention, but nothing worthy of note was found in the Tertiary rocks of the Boundary Creek Sheet.

* Bulletin of the U. S. Geol. Survey, No. 193—Geological Relations and distribution of Platinum and associated metals. J. F. Kent.

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Petroleum.—Borings for oil are being made on the banks of a pond just west of Observation mountain, near Grand Forks. Since the rocks are all crystalline or igneous, of very complicated structure, the discovery of oil in any quantity would be entirely opposed to all past experience in the occurrence of mineral oil. So far oil has been found to occur where there is organic material present to furnish the hydrocarbons, a porous rock present to retain the oil, and an anticline or some such structural feature which would furnish room in which it might collect. None of these conditions are present in this district.

Clay.—Clay suitable for brick-making occurs in the neighbourhood of Grand Forks, on Eholt creek, Lind creek and elsewhere.

Serpentine.—None of the serpentine seen was sufficiently massive to be useful as an ornamental stone. In White's camp a very pure soap-stone occurs which, near transportation and a market would have an economic value. In the same locality some fibrous serpentine occurs (chrysotile asbestos). None of the fibres seen possess the requisite quality for commercial purposes.

Building Stones.—The granodiorite of Greenwood is quarried as a building stone, for which on account of its jointing and quality it is well adapted. Some of the syenite porphyry dykes exposed on the railway cuts would make good building and ornamental stones. The Tertiary tuffs and sandstones where accessible as at Phoenix and near Midway, would also make good building material.

Marble.—Some of the crystalline limestones are sufficiently massive and pure to make good ornamental stone, but they are not always accessible. Many are also suitable for burning into lime.

The occurrence of clay with these limestones would make a cement industry possible if there should ever be an available market.

HINTS TO PROSPECTORS.

Since there is a great deal of similarity between the geological conditions in the Boundary district, and those of other parts of South-western British Columbia, so far as they are known, it is quite likely that the experience gained in the Boundary Creek district may be applied in the districts west of it. Some of the results of observations in the Boundary district may be summarized as follows:—

Ore may be found in any of the Pre-Tertiary rocks where conditions for mineralization were favourable.

Conditions under which mineralization has taken place.

The chief condition for mineralization appears to be heavy Tertiary volcanism. Ore occurs, (1) near vents through which the volcanic rocks reached the surface: and (2) where the country rock is extensively dyked by the pink or gray alkali-syenite porphyry. Limestone contacts in such areas should be prospected with particular care.

On account of the irregular form which the ore bodies may possess and the complex nature of the rock formations, a careful and detailed study of the surface of the ground in the neighbourhood of the mines would be of great practical assistance in the exploitation of the ore bodies. For the same reason development work must always be kept well ahead of the actual mining. Cross-cutting must frequently be resorted to, to determine the actual limits of the deposits, and to prove the existence or non-existence of parallel ore shoots. The limits of mineralization must be actually proved, and similarly, only that ore can be with certainty reckoned on which has been actually blocked out. In this connection diamond-drilling can be resorted to with advantage.

Magnetic methods of prospecting.

Prospecting by means of magnetic surveys might sometimes be successful, so far as the magnetitic and pyrrhotitic ore-bodies are concerned. Since much of the surface is drift-covered, and the ore-bodies do not as a rule have any oxydizing effect on the soil above, this is often the only way in which any indication of the spot where a test pit should be sunk can be obtained. It might also be applied in searching for ore-bodies in the mines themselves. It has not yet been attempted in this district.

Where the ore occurs at a limestone contact, the limestone wall may often be used for following the ore, it being kept in mind that the ore does not always follow strictly along the contact, and that the limestone may pinch out without causing the ore to likewise disappear. The dykes in some cases may be used in the same way.

The pyrrhotite and magnetite should always be assayed, as barren-looking material may carry good pay values. The minerals in the ore and the conditions where pay values occur should be carefully studied with a view to ascertaining which minerals carry the values, and what were the causes which produced the concentration of values. The porphyry dykes themselves, while not mineralized in the same way as the country rock, may in places prove auriferous. In a specimen from a similar alkali-porphyry dyke, from the Valkyr mountains, east of Lower Arrow lake, examined last winter, free gold as a primary constituent was plainly visible, even with the naked eye.

Since, with the exception of certain deposits in Copper camp, there is no zone of oxydation and secondary enrichment in the large deposits, while the general conditions remain unchanged, no loss of values is to be expected in depth.

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Platinum should be tested for in the copper ores and in the quartz Platinum. ores. Gravels of streams draining areas of serpentine should be panned for platinum. In places the nuggets are sometimes brown or lead-coloured, but become silvery white when treated with nitric acid. The serpentines themselves, especially where containing chromite (a magnetite like mineral), might be assayed for this metal.

In the oxydized type of copper deposit a zone of enriched sulphides occurs between the oxydized minerals and the pyrites. Below this zone of enrichment the deposit may or may not have sufficient values to pay for working. Sufficient work has not been done to determine the lower limit of the zone of enrichment.

The quartz veins merit more attention than has been given them.

In prospecting it is to be remembered that float may have been carried a considerable distance, even across valleys, by former glaciers. The general course of the latter was about S. 30° E., but it was influenced by the local topography.

PRODUCTION.

While a little high grade quartz ore was shipped from the district by pack train, ore production may be said to have commenced in 1900, after the completion of the Columbia and Western railway into the district, and of the Granby and Greenwood smelters. Since that time the approximate tonnage shipped and smelted is as follows :—

—	1900*.	1901*.	To Nov. 30, 1902.	Approximate. output for 1902†.
	Tons.	Tons.	Tons.	Tons.
Knobhill-Ironside	64,531	231,762	286,691	310,691
Mother Lode	5,564	99,548	122,577	137,577
B. C.	19,618	47,517	11,627	14,627
Golden Crown	2,241		625	625
City of Paris	2,000			
Winnipeg	1,076	977	785	785
Snowshoe	297	1,731	15,540	20,800
Athelstane	1,200	550		
King Solomon		850		
No. 7		665	532	532
Sunset and Crown Silver		800	6,750	8,010
Jewel	160	325	2,175	2,175
R. Bell		480		
Brooklyn	150			
Ruby		85		
Emma			6,700	7,900
Providence			132	172
Small shipments	1,000	500	158	158
Totals	97,837	386,675	448,602	503,962

* Minister of Mines Report for British Columbia, 1901.

† Engineering and Mining Journal.

The production for 1902 will exceed the total previous yield, in spite of the fact that a shortage in coke, caused by the Fernie strike, necessitated the closing down of the smelters and mines during part of July and August, and that lack of power at the Granby smelter, due to exceptionally low water, has, all fall, prevented the smelter from running full blast. Practically all the ore produced is treated in the smelters of the district. Since the completion of the branch of the Great Northern Railway through Grand Forks to Republic, some Republic ores have also been shipped to the Granby smelter for treatment.

Smelters.

There are three smelters in the district: the Granby at Grand Forks, the B. C. Copper Co.'s at Anaconda (Greenwood), and the Montreal and Boston at Boundary falls. These plants are modern and first-class in every respect. The Granby smelter has a sampler of 2,000 tons per day capacity, four furnaces with a capacity for these ores of 380 tons daily each, a briquetting plant for flue dust and two converters with all the necessary and accessory plant. Electric and hydraulic power operate numerous automatic and labour-saving devices. The matte from the other Boundary smelters and from the Hall Mines smelter at Nelson, is sent here to be converted to blister copper. It is proposed to increase the plant by two more furnaces.

B. C. Copper Co.'s smelter, Greenwood: The plant consists of ore bins, sample mills and two 2,300 ton furnaces, arranged on a gravity system so as to require a minimum of energy and labour. During January, one 300-ton furnace smelted on an average $428\frac{3}{8}$ tons of ore daily, with a record run of 460 tons of ore in 24 hours. From these figures the remarkable adaptability of Boundary Creek ores to smelting is readily perceived as well as the skill with which the smelting operations are conducted.

The Montreal and Boston Copper Co., have taken over the Pyritic smelter at Boundary falls to treat their ores from the Sunset and Crown Silver. This smelter, which was built for pyritic smelting, was never operated as such, and has now been fitted up for ordinary smelting. The plant consists of one large furnace and a sampler. A second furnace is contemplated.

BRIEF HISTORY OF THE DISTRICT.*

The first man in the district was Charles Dietz of the Riverside Hotel, who came in, in 1857; 'Old Jolly Jack' Thornton, who still resides in a cabin on Boundary creek, was the second man. Boundary

* Most of the statements herein made are based on information supplied by John East, one of the early pioneers.

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creek was worked for placer gold, in 1862, a small town being located south of the International boundary line. In 1884 the first mineral claims in southern B. C. were staked, the Victoria and Washington, afterwards Old England, located on Rock creek a few miles above Kettle river. The same year two of the pioneer prospectors, John East and W. T. Smith came to the Boundary creek district, and in 1885 they located the first claim in the district, the Rocky Bar, now the Tunnel on Boundary creek near the falls. The same year they also located the Non-such in Smith's camp. First location.

In 1886 the Bruce claim on Ingram Mount was located by East.

In 1887 George and David Leyson and Geo. Y. Bowerman located the Big Copper, as the Blue Bird. They went on through to Trail creek, where they made some locations around what is now Rossland, but they allowed their claims to lapse. The King Solomon was located by Lefabre and Lynch, who threw it up. In 1888 it was acquired by D. C. Corbin. In 1890-91 there were some locations made by James Attwood and John Lemon around the Buckhorn. On May 23, 1901, the Mother Lode was staked by William McCormick and Richard Thompson, and on June 2, John East located the Sunset and Wm. Ingram located the Crown Silver.

The same summer the pioneer prospectors crossed over to what is now Phoenix. Matthew Hotter located and named Knobhill. Attwood located the Brooklyn and Summit camp. Scott McRae, Geo. Taylor, Henry White, Geo. Rumberger and others also made locations, White and Attwood, in particular, locating White and Attwood's camps. The Providence was located in 1891 by Dickman.

In 1892 Howard C. Watters brought in a 2-stamp mill, which was set up at Boundary falls to treat the quartz of Boundary falls and American bay claims. The Providence shipped about 45 tons of ore, which is said to have netted \$15,000. The Skylark is said to have shipped \$25,000 or \$30,000 worth of ore. Interest in the low grade ore bodies in the early days is said to have been awakened by Scott McRae, who made a trial shipment for outside capital, and by E. P. Sudam, who sampled the ores and brought in outside mining men. The town site of Midway, formerly known as Eholts, was acquired by Capt. R. C. Adams and associates of Montreal, in 1893. The site of Greenwood was acquired in 1895 by Robert Wood, who immediately founded the town. Grand Forks was one of the earliest settlements. On the advent of the Columbia and Western railroad most of the camps sprang suddenly into incorporated towns. The chief towns of Stamp mills.

the district are Grand Forks, Eholt, Phoenix, Greenwood, Anaconda and Midway, with small settlements at Deadwood, Boundary falls and Carson.

Present
population.

The population of the district is supposed to be in the neighborhood of 10,000. The chief industry on which practically all the others depend is mining. The attendant industries and occupations are fully represented. Lumbering is carried on to some extent and ranching is becoming important. It is found that the lower valleys are admirably adapted for fruit growing, and apples, plums and strawberries of prime quality are now being cultivated. The mining camps and towns afford a good market for all such produce.

GEOLOGY OF THE WESTERN PART OF THE INTERNATIONAL BOUNDARY (49TH PARALLEL).

Dr. R. A. Daly.

I left Ottawa on May 27 and joined the Boundary Survey party under Mr. W. F. O'Hara, D.L.S., at Greenwood. Active field work was begun on June 5 and, owing to the unusually favourable weather this season, continued with but few interruptions until the middle of October. My field expenses were, as last year, paid through Mr. King, our Chief Commissioner, by the Department of the Interior, but the wages of my assistant, Mr. F. Nelmes, were this season paid by the Geological Survey Department. The geological work of the summer was divided into two parts corresponding to different sections of the Boundary belt traversed by our party. The following sketch is a brief business report of the work done, embodying a few preliminary and general considerations on the areas covered.

Reconnaissance
work.

During a rapid journey from Midway to the Similkameen river Mr. O'Hara collected information additional to that secured last year for the completion of the topographic map of that section. In this way I was enabled to have a preliminary view of its geology; material was gathered which will be of value in a future more detailed geological examination. Three weeks were thus devoted to the reconnaissance of this section of the Boundary country. The belt measures 43 miles in length by from 4 to 5 in breadth; a greater width could not be covered because of the fact that the main camp, to which I was attached, was often compelled to locate on or south of the line, while it seemed best to concentrate attention to the Canadian side so far as my own work was concerned.

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The whole belt lies within that division of the Cordilleran Mountain System called by Dawson "The Interior Plateau"; it is situated between the Coast (Cascade) range on the west and the complex, rather indefinitely bounded Gold ranges on the east, and forms that zone of the Rocky mountain region of the least strength of relief. In the 43-mile section examined this season the altitudes of the highest summits rarely exceed 5,000 feet above sea-level. The deepest valleys are those occupied by Osoyoos lake and the Similkameen river at its eastern crossing of the 49th parallel of latitude. The lake is almost exactly 1,000 feet above sea-level, and the river is at approximately the same altitude. The average elevation of the higher ridges and rolling hills of the belt is not far from 4,500 feet above sea-level.

Topography
west of
midway.

The whole of the topography is the immediate product of long continued denudation which has gone considerably further than in the coast range studied last season. In this central part of the Cordillera the alpine horns, serrate ridges, amphitheatres, etc., are absent and, in their stead, the relief is composed of an irregular assemblage of old mountains, low domes, sugar-loaf forms and ridges of relative tameness in aspect, all rounded into the profiles characteristic of mountains that have long suffered erosion by streams and as long suffered loss during the slow but sure streaming of rock debris down the slopes. These slopes are thus of the type called 'graded,' i.e., they are generally of a degree of steepness whereby the loose material weathered off from the bed-rock can assume the form of long, smooth slopes of waste mantling the hills from top to bottom. Bare rock-surfaces in such topography are much less common than in truly alpine, younger mountains.

An important consequence to both the geologist and the prospector is found in the comparative inaccessibility of the bed-rock, covered as it is by the waste. The study of rock-distribution and structure as well as the discovery and exploitation of mineral deposits are, for this reason, more difficult in such mountains than in those characterized by ungraded, alpine slopes. This general fact must never be forgotten in estimating the economic importance of the Cordilleran zone, now called the 'Interior Plateau.' It is, for example, highly probable that the Similkameen district will repay much initial expense in boring for coal even where the prospector has but few outcrops of the coal or its associated formations to guide him in the development. In other words, the few natural exposures of mineral-bearing strata, veins, etc., in 'graded' mountains are worthy of specially energetic study by miners and government surveyors, more for what they indicate concerning mineral deposits buried under the adjacent 'wash' than for their own particular mineral contents. The economic development of the

Relation of
topographic
developments
to mining.

'Interior Plateau' must, therefore, be relatively slow and expensive, but, as it becomes settled and intelligent prospecting continues, it may prove to be as rich in mineral resources as any other part of the Cordilleran region.

Evolution of
the topog-
raphy.

From the experience gained on the reconnaissance, rapid as it was, I am forced to consider it as inadvisable to describe the region as part of a 'plateau.' Such a name would imply that the area once formed a portion of a more or less continuous, flat-topped or gently rolling, elevated tract, and that the existing diversity of relief is the effect of erosion acting through a long period of time on that block of high land. Such is the view advanced by Dawson for the 'Interior Plateau.' His evidence for it was derived from the study of the northern part of the same mountain-zone lying on either side of the main line of the Canadian Pacific Railway (of the Kamloops sheet and corresponding report by the late director of this Survey). The preparation of the simple, flattish surface of the 'plateau' in this zone of enormous structural complexity is ascribed by Dawson to the prolonged erosion of the crumpled Paleozoic and Mesozoic strata composing a once lofty range. In this way, provided time enough were allowed, an almost perfect plain of denudation (a peneplain) would be produced. Strong bodily uplift of the denuded area would, then, by the theory, give the elevated 'plateau.' On its surface the streams would be given renewed power to lower their channels, deep and narrow at first, deep and flaring open later on in geological time. To such activity of streams in a second 'cycle' or era of denudation, Dawson attributed the great and small valleys sunk in the 'plateau,' and in accordance with his theory, the second period of erosion was responsible for nearly all the existing diversity of relief in the extensive 'Interior Plateau.'

Along the International boundary, however, the evidence for two such cycles of denudation is but slight. The chief positive criterion for the previous existence of an undissected plateau underlain by truncated strata folded and faulted by mountain-building, is the discovery of remnant areas of that plateau not destroyed by erosion. Such remnants seem to fail entirely between Midway and the nearest outlier of the coast range, the Okanagan mountains. The mountains have not the broad, flat tops expected, but are generally of conical or ridge-shaped form, such as belongs to a range worn down in one cycle of denudation. The accordance in altitude of the summits is far from being perfect, and such accordance as does exist can be explained by other conditions of mountain sculpture. Further study of this topo-

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graphy will be facilitated when Mr. O'Hara's final topographic map of the belt is completed.

In the glacial period, the Cordilleran glacier, moving southwardly between the Coast range and the wall of the Gold ranges, completely covered the highest summits in the belt. The result has been to disturb the pre-glacial mantle of rock-waste which lay on the old mountains. The loose rock-material was, however, not carried far, and it is probable that the amount of such material now resident in the belt in the form of boulder-clay, stratified glacial gravels, sands and clays, is at least as great as before the ice moved over the country. The field observations agreed in showing an enfeebled erosive activity of the great glacier in this part of its course. Its terminal moraines are not far to the southward across the Boundary line, and the great abundance of drift and but slightly modified pre-glacial rock-waste indicate that the glacier was depositing its load of *débris* rather than scouring off the products of weathering from the rock-surfaces whence they were derived. The conditions recall the useful parallel that has been made between glaciers and rivers. At the lower end of each the geological work consists chiefly in deposition, a delta corresponding to terminal and ground moraines. Added to the evidence of slight glacial erosion as indicated by the deposits, is that derived from the fact that well-developed *roches moutonnées*, striated, grooved and still firm, are notably rare.

The glacial veneer of rock-detritus thus left on even many of the summits as well as in the valley bottoms, often corresponds in depth, continuity, and surface configuration to the pre-glacial veneer of weathering products expected from the secular decomposition of the different formations of the belt. Access to bed-rock and prospecting for mineral deposits are therefore almost as difficult as if the country had never been glaciated. Compensating in some degree for this disadvantage, perhaps more than compensating for it, the veneer of decomposed rock-matter, often affording rich, strong soils, will more and more prove to be a valuable asset to the country, since full varied crops can be grown upon the veneer, not only in the valleys, but often far up towards the summits of the intervening mountains.

As in most glaciated regions, the glacial sands, gravels and till of the valleys have been extensively terraced by the respective streams. Fine examples of such terraces were seen along the west fork of the Kettle river. Both there and elsewhere in the belt, excellent illustration was found of the influence of rock-spurs from the adjacent mountains in preserving the terrace-deposits as they may now be seen.

Glaciation
west of
Midway.

Stream-
terraces.

These spurs have controlled the meandering of the streams in such fashion as to restrict the width of the meander-belt more and more as the streams have cut down their channels. The upper terraces have, for this reason, not been undercut and destroyed in the later swings of the meandering streams. Excellent farmland has been preserved thereby and it forms a considerable part of the economic resources of the region.

**Terraced
alluvial cones.**

An interesting special feature of this channel-sinking is illustrated at many points in the belt, but again best of all in the valley of the Kettle river near Midway. Large, more or less symmetric and regular alluvial cones or steep-slope fans of rock-detritus have been washed out of the terrace-sands from lateral gorges. As the main river to which the drainage of the gorges is tributary, swings to the foot of one of these cones, the cone may be partly cut away and thus truncated, and the 'base level of erosion' of its perennial or wet-weather stream is lowered and the cone cut away by that stream. Dissected cones regularly terraced by the repetition of this process are well displayed along the almost treeless valley-walls of the Kettle and other rivers. Just north of the town of Midway, a young, inner cone has been built up in the deep, flaring notch of a terraced older cone since the time when the Kettle river swung away southward to its present position. The whole complex form shows how sensitive are the degradation and 'aggradation' of alluvial material to changes in the position of the base level of erosion.

**Geology west
of Midway.**

Until the topographic maps of the boundary belt surveyed this season are finished, it is impossible to present a report of enduring value on the distribution and structure of the solid rock formations met with. The reconnaissance of the belt from Midway to the Similkameen river resulted in the recognition of at least five chief divisions of its rocks. Oldest of all is a group of crystalline schists, mica-gneisses, mica schists, granites and granitoid gneisses occurring on the shores of Osoyoos lake. These are of great but unknown age, older than a second division of rocks also enormously plicated, cleaved and broken in the stress of mountain-building. This second group is composed of phyllites, slates, quartzites, chloritic schists and amphibolites with highly altered greenstone and true volcanic bands. Certain lenses of crystalline limestone are also provisionally referred to the same great series. Throughout its extent, but more especially in the phyllitic and slaty members, quartz veins, often of huge size occur, but so far, they have proved to be practically barren of the precious metals. This thick and important series of rocks outcrops at intervals

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from the meridian lying about seven miles west of Midway nearly to the Similkameen. No fossils were discoverable.

Unconformably overlying the metamorphic group are outliers of Tertiary sedimentary rocks; light and dark gray sandstones, grits, conglomerates and shales, all greatly disturbed and so much destroyed by erosion as to represent but a small part of the once thick and continuous formation, doubtless at one time covering the entire belt. Leaves and stems of exogenous plants of Tertiary habit were found in the sandstones of a long monoclinal section on the wagon road about four miles west of Midway; and again in the gulches tributary to the Kettle river near the bridge about two miles farther up stream; and finally, from a well-exposed section in the canyon of Rock creek. Partly interbedded with, but for the most part overlying the sandstones and shales, are thick, basaltic and andesitic lava flows, tuffs and agglomerates which have shared the dislocations to which the sediments have been subjected. Numerous dykes and laccolithic masses of varied porphyrites cut both sediments and lavas. The exact age of these rocks cannot be stated until the fossil collections are determined.

Several intrusive stocks, batholiths and many dykes of diorite, gabbro, granite and of an interesting syenite of alkaline character, cut the formations older than the Tertiaries, although, on account of their unsqueezed condition, it is believed that, in general, these eruptives are of later date than the fossiliferous beds and overlying lavas. Rather liberal collections were made from this great array of intrusive and extrusive igneous rocks; the microscopic study of these during the coming winter will form a valuable aid in the next detailed study of the belt.

Excepting the auriferous gravels of Rock creek, which have been Minerals. worked in a desultory fashion for forty years (now almost entirely by a few resident Chinamen), there is no mineral deposit proved to be of economic importance in the belt. Indications of copper in the form of the common sulphides, occur in narrow quartz veins occupying zones of fracturing in mineralized quartzite on the Kettle valley slopes two miles north-west of Midway, but they do not appear to warrant development. Other narrow quartz veins containing the tellurides of gold and silver (calaverite and hessite) are reported from the diorite found on the northern end of Osoyoos lake, west side. East of that lake, a three-foot vein of pegmatite, bearing cassiterite, has likewise been reported by a prospector as cutting the coarse granite. No opportunity was afforded for visiting these localities during the reconnaissance.

Seams of lignitic coal are embedded in the sandstones and shales of the Rock creek Tertiary, but none of them yet discovered is thick enough on the surface outcroppings to be worth exploitation.

Main division
of field-work.

The larger part of the field season, from July 1 to October 15, was devoted to more detailed study of a second belt adjacent to the boundary line. The belt measures 10 miles in width and 51 in length, extending from Cascade City on the Kettle river to a point 5 miles east of the Salmon river and near the watershed between the Columbia and Kootenay rivers. Part of the area is covered by the one-inch-to-one-mile Trail map-sheet, already issued by the Geological Survey. In that section of the belt, attention was chiefly given to the delimitation of the formations found just north of the boundary but not differentiated on the preliminary edition of the Trail sheet, the only edition yet issued. Since the Rossland camp, on account of its importance, needs special investigation at once by a party spending at least two seasons in the camp, little time was this year taken in the field study of the district immediately surrounding the city.

Topography
in the Gold
Ranges.

The whole 50-mile belt lies in that irregular zone of the Cordilleran mountain system generalized by Dawson under the name of the Gold Ranges. The relief is stronger than in the park-country, in which the party spent the earlier part of the summer. The summits here reach altitudes of over 7,000 feet and overlook the Columbia river at 1,400 feet above sea-level. These mountains, however, rarely assume an alpine form, but usually present the appearance of rounded, forest-covered ridges and domes characteristic of the southern part of the Gold Ranges. The greater abundance of rock-exposures both in the river canyons and on the summits makes geological study less difficult than in the 'Interior Plateau,' but this feature is offset to some extent by the thick forest which impedes the progress of the explorer to a marked degree in all parts of the belt except on the highest summits.

Crystalline
rocks.

The terranes encountered are for the most part highly crystalline, partly crystalline schists, partly igneous formations. Until microscopic examination of the collections from the different rock-members is made, no account of essential value can be given of conclusions derived from the field observations made on these rocks. Some idea of the great variety in the igneous formations may be gathered from the fact stated verbally by Mr. Ferrier, formerly official petrographer to the Geological Survey, that, within a radius of only 5 miles from Rossland, 108 rock-types have already been discovered. All of the formations except the later dykes and intrusive stocks have been intensely folded and faulted and subsequently so deeply eroded as to give little immediate evidence as to the geological history of the region.

About one-third of the belt is underlain by metamorphic rocks. At its extreme western end, a small patch of foliated, coarse, biotite gne-

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isses, cut by pegmatite veins and by dykes of peridotite, represents an Archaean (?) band entering the belt from beyond Christina lake and the Kettle river. A much more extensive, thoroughly crystalline series of crumpled schistose rocks occupies most of the belt between its eastern limit and the Salmon river. This series includes quartzites, phyllitic, chloritic and sericitic schists, biotite schists, thick pods of crystalline limestone, amphibolites, etc. Much of this series has been referred by the first reconnaissance of the Geological Survey, to the Selkirk series. It seems to be unfossiliferous throughout and offers the characteristic difficulties in unravelling structure and plotting boundaries that every worker finds in the Gold ranges. Lying geographically between the first two series is a third, exposed best in the phyllites, quartzites, slates and marbles of the Pend d'Oreille canyon. Indirect evidence suggests a Carboniferous age for this third group of metamorphic rocks.

Upon these complexly folded schists, the extensive volcanic deposits associated with the ore-deposits of Rossland, were laid down. Basaltic, andesitic and more acid lavas, flows, tuffs and agglomerates, cover at the present time a second third of the belt. Erosion has not only swept away much of the thick volcanic veneer from its basement of crystalline schists, but has brought to light several large stocks of granites and syenites intruded into the volcanics since the latter were erupted, folded and faulted. Abundant but obscure remains of endogenous plants of late Mesozoic or Tertiary habit were found in certain slaty ash-beds occurring at the crossing of Little Sheep creek by the Boundary line. These fossils, when determined, should throw light on the age of the older volcanics of the Rossland series. Fossils.

Still younger than the plant-bearing beds and the overlying volcanics, is a fifth series unconformably related to them. It is not important either economically or with respect to the area covered, but has interest on account of the light it throws on the geological history of the region. It consists of various patches of, probably contemporaneous, unfossiliferous sediments lying on the older agglomerates and on the phyllitic (Carboniferous?) formation. The rocks composing these patches are coarse conglomerates and sandstones, sometimes accompanied with tuffs and lava flows of basic composition. The patches are believed to be of Tertiary age, remnants of what is, for the most part, regarded as an irregular, necessarily more or less interrupted, group of river-gravels strongly cemented since being deposited. Rocks probably of Tertiary age.

Numberless dykes belonging to several different epochs of intrusion, cut these five formations and the stocks and batholithic masses which,

for convenience in a preliminary statement of the work done last season, have been roughly and with extreme brevity, here distinguished.

The mechanism of igneous intrusion.

Among the more pressing problems belonging to the general geology of the belt is that one referring to the method or methods according to which the intrusion of the granites and syenites of the great intrusive bodies took place. It became clear to me from a study of the facts observed in the field, that none of the existing theories of intrusion adequately explains the conditions characteristic of these stocks and batholithic bodies. The origin of the subterranean chambers once occupied by those bodies, and the process by which the invaded formations were so far displaced by the irruptives, form different phases of the same problem; their discussion has to do also with the origin of the abundant igneous rocks of the belt. It has been considered advisable to present in a generalized form, the hypothesis derived from the field-studies of the past two seasons in the Boundary as well as from earlier investigations of eruptive areas, rather than to note specially in this report the concrete phenomena observed during the season just closed. (The statement of the hypothesis will be given in two papers appearing in the *American Journal of Science*.)

Glaciation.

The glaciation of the belt led to more severe erosion and more complete removal of rock-débris than in the region west of Midway. The drift is consequently less abundant and the rock-exposures more numerous. The upper limit of glaciation was definitely fixed on Record Mountain ridge west of Rossland and elsewhere in the belt, as very close to 6,400 feet above the sea. The south-flowing Cordilleran glacier was, at its maximum, 5,000 feet thick over the axis of the Columbia River valley. Many horns and ridges at that time, projected above the ice as 'nunataks.' Above the 6,400-foot contour, the summits are covered with felsenmeers or mantles of often deeply decayed angular rock-fragments slowly streaming down the slopes. The relatively few ledges there exposed are ragged, greatly weathered and, like the felsenmeers, bear no drift. The contrast with the glaciated slopes below is always sharp and striking.

Mineral deposits.

Since the main purpose of the survey along the Boundary is that special one of developing as far as practicable a detailed structural section across the whole Cordillera, not much time could be devoted to the different, though connected, problems of the mining geology of the belt. Many claims and a few working mines were, however, visited, and data collected which will be used in the preparation of the final report on the Boundary. Of particular interest was an extensive deposit of hematite, largely limonitized, occurring in the marbles on

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the north side of Boundary creek about one-half mile up stream from its confluence with the Pend D'Oreille. The ore-body has been traced on the outcrop for a distance of a mile and a half. It is of variable thickness, but the degree of the variation could not be fully determined because of the lack of time and of natural exposures at many points desired. A tunnel has been driven forty feet into the solid ore where it crosses Boundary creek but much development work will be necessary beneath the deep wash before an accurate account of the prospect can be given. A few grains of pyrite were seen in ore-fragments taken from the dump at the tunnel; failing the required assays as yet, it is impossible to be certain how far the ore is injured by the sulphide. Partial assays reported by Mr. Feeny, one of the co-owners of the property, showed 59 to 61 per cent of iron in the ore, which is thus of high grade quality. The apparent strength of the ore-body, the proximity of abundant flux material, of wood for charcoal furnaces, and the easy access to the property from the Nelson and Fort Shepard Railway, render the deposit worthy of special attention. It is highly probable that other similar deposits will be found on further prospecting in the vicinity. Marbles of economic value may also be expected to occur as phases of the thick masses of crystalline limestone lying between the Pend D'Oreille river and the Salmon river.

The general rock-types and structures characteristic of the Rossland camp are known to be represented in other parts of the igneous formations to which they belong, and smaller ore-bodies similar to those at the camp have been discovered at points distant from the city. It is therefore possible that other copper-gold ore bodies of importance comparable to that held by the deposits of the famous camp will be found elsewhere in the volcanic series. Quite different, low grade gold, silver, and copper deposits in quartz-veins have been staked out in the schistose formations lying east of the Salmon river. So far, the tonnage of ore-bearing quartz exposed at any one of these claims is so small as to forbid active development. Many quartz-veins in the schists and quartzites forming the rough sierra between the Salmon and the Kootenay, run from 25 to 150 feet in width. Thorough prospecting among these, checked by numerous assays, may yet reveal precious metal deposits of great value, though they must be expected to show only low-grade ore. The most favourable outlook will be for free-milling gold-quartz.

The auriferous gravels in the abandoned former channel of the Pend D'Oreille river were among the first deposits to draw the attention of the mining world to the province of British Columbia. The gravels at Boundary Town seem now to be practically worked out and no min-

Auriferous
gravels.

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Okanagan lake.....	23	45	east.
Cascade City, Kettle river valley.....	22	50	"
One mile east of Cascade City.....	22	15	"
Five miles " ".....	22	10	"
Top, Sophie mountain.....	23	00	"
West slope, Sophie Mountain.....	23	45	"
Little Sheep creek valley.....	24	00	"
Columbia river, Boundary Town.....	22	50	"
Summit, five miles east of Pend d'Oreille river.....	23	00	"
South Fork, Salmon river.....	22	45	"

NOTES ON THE GEOLOGY OF ANTHRACITE, ALBERTA.

Mr. H. S. Poole.

A visit was paid in November to the coal fields of Anthracite on the Bow river, where the Canadian Pacific railway enters the Rocky mountains. Through the courtesy of Mr. O. E. S. Whiteside, B. Sc., the superintendent of the mines, an opportunity was afforded me of going underground, and also of seeing the carefully kept plans of the workings.

So far as the general structure of the field is concerned (further than the discovery of additional seams in the series) but little more information has been acquired from surface exploration than was known when the Geological Survey Report for 1885, B. 1261, was issued, but the mining operations have exposed a series of foldings of the coal-bearing beds throughout the valley of some complexity.

In much of the Cretaceous rocks occupied by the valley of the Bow river in this locality, the river has at some time or other taken its course, and by its shifting channel cut the coal-bearing series down to the general level of its present bed. At a later date the valley has been filled with well-worn gravel, in some places to a depth of as much as 200 feet; and this deposit the river is now engaged in removing, but still leaving broad terraces which in some spots no doubt cover over and hide from view outcroppings of the coal strata. It is doubtful if the river has got down to the level it occupied before the deposition of the terrace gravels, and until this has been determined additional caution has to be exercised when mining coal on the uprisings of the secondary folds below the stream, lest connection be unexpectedly made with the water-soaked gravels of an ancient channel. The slope on 'A' seam has been carried down 684 feet.

The coal seams crop on the northern side of the valley, with a varying degree of inclination to the southward, but so far a continuity

Connection
with coal of
Canmore not
proved.

Folds of
strata.

Faults.

of the seams of anthracite with those of bituminous coal at Canmore, ten miles distant, has not been traced, and no natural exposures are known in the intervening ground. To the northward, on the Cascade river where the same series is exposed, explorations have been made and prospectors report finding the quality of the coal change from anthracite to bituminous within a remarkably short distance. On the south side of the valley there is also a lack of natural exposures and heavy deposits of gravel interfere with the development of the structure to the deep of the workings along the crop. Underground operations have sufficiently exploited the field to show that the strata have been thrown into folds, having a course somewhat diagonal to the general line of strike. N.W. and S.E., and more to the southward. The chief folds incline and broaden in that direction, but their determination has not been made out. It may be suggested, however, that cross faults, with downthrows to the S.E., carry them to the north-east, near the junction of the Bow and Cascade rivers. The workings at Anthracite proved one such main fold, with a southerly dip varying from 20° to 50° , and with the axis of the trough directed to the south-east and turned up rapidly to the vertical, or in places overhanging on the south side. This south side has been followed upwards for 300 feet, but the structure still further southward has not yet been proved. Further down the valley, a lateral displacement of over 2,000 feet is presumed to have occurred, and while the orogenetic movements have not, at Canmore, eliminated much of the volatile matter of the coal, they have greatly altered the associated measures.

Mr. Whiteside does not consider he has yet obtained sufficient data to satisfactorily describe and illustrate this field, but from operations now in progress at Canmore, he hopes shortly to be enabled to do this.

Sections
given by Mr.
Whiteside.

The following are revised sections of the coal seams of the Anthracite series, in descending order:

	Ft.	In.	Ft.	In.
'B' seam:—Mining	1	0		
Slate	0	7		
Coal after-slating.....	4	4		
Slate	0	$0\frac{1}{2}$		
Mining	0	$5\frac{1}{2}$		
Measures			6	5
			125	0
'A' seam:—Mining	0	3		
Coal	1	0		
Slate	0	$1\frac{1}{2}$		
Coal	4	$9\frac{1}{2}$		
Mining	0	2		
Measures			6	4
			110	0

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No.1 seam :—Bone and dirt	1	3		
Coal	2	0		
Slate	0	2		
Coal	0	5		
Slate	0	2		
Mining	1	2		
Slate	0	1		
Coal	0	5		
Slate	0	4		
Coal	1	2		
Mining	0	2		
			7	4
Measures			90	0
No.2 seam :—Coal	2	2 to 3 ft. 3 in.		
Slate	0	4		
Mining	0	6		
			3	0
Measures			84	0
Mining	0	10		
Coal	1	2		
Slate	1	6		
Coal	1	8		
			5	2

THE REGION SOUTH-WEST OF FORT SMITH, SLAVE RIVER, N.W.T.

Mr. Charles Camsell.

The following report is based on work which was carried out during the season of 1902, in the country to the south-west of Fort Smith, in the angle between the Peace river and the Great Slave river. Area included in report.

On receiving my instructions from Dr. Bell, I left Winnipeg on June 3 for Edmonton, where I spent a few days in obtaining supplies and making other arrangements for my trip. Here I also hired Duncan Mackay as canoe man, and he was my sole companion for the greater part of the summer. The trip to Athabasca landing took much more time than is usual, owing to the fact that nearly all the bridges had been washed away by the unusually high water, and our canoe which we were also transporting was very useful in ferrying supplies across the streams.

We reached Athabasca landing on the 16th and left next morning for Fort Smith in our canoe. The rapids on the Athabasca river were run without any mishap, and we arrived at Fort Smith on July 1.

A canoe trip up the Salt river being part of the programme laid down in my instructions, I decided to make this at once before the water Track survey of Salt river.

got too low for navigation, and, even at this date I was informed by the residents of Fort Smith that I would not get far up. However, we left Fort Smith on July 3, and spent a week in making a track-survey of Salt river, as well as an examination of the country on both sides of the stream. Mr. McConnell in the summer of 1887 ascended Salt river as far as the brine springs, and his account appears in the reports for that year. We were only able to get about 20 miles higher up than Mr. McConnell, when the stream became too shallow and choked with trees, for canoe navigation.

Salt springs.

The Salt river enters the Slave river about 18 miles below Fort Smith, and is about 40 yards wide at its mouth. At the time we passed up, it had little or no current for some distance. The water is quite fit for drinking for about three miles up, but above this becomes more and more salty until we get to the brine springs at the forks of the river. Above this the amount of salt held in solution decreases in quantity, but the water is still unfit to drink. Its general direction is about south (magnetic) as far as the forks at 20 miles from the mouth, then it turns sharply to the east and was still flowing from this direction when we turned back.

Five miles up from the mouth, the banks of the stream suddenly rise from five feet to thirty feet and are of alluvial origin; beyond this point the height gradually decreases to the springs, where it is only about six feet, but on going higher up stream and away from the Salt plain, the banks soon reach their former height of thirty feet. This would show that the Salt plain, which runs parallel with a steep escarpment to the west of the river, lies in a depression that is greatest just along the base of this escarpment.

Steep escarpment.

The escarpment itself is about 210 feet high, with a rather steep slope, generally well wooded with poplar and spruce, but showing here and there outcropping strata of limestone, and running in a general direction about north-west and south-east. We entered the Salt plain about ten miles above the mouth of the river; though from the river one does not notice it, as the banks are everywhere thickly wooded by a belt of timber 100 to 200 yards in width. The greatest breadth of the Salt plain does not exceed eight miles from north-east to south-west and its least breadth is about two miles. Its length could not be determined accurately; but I know that it is at least fifteen miles. It is by no means an unbroken stretch of prairie land, but is interspersed at short intervals with clumps and groves of poplar and spruce; and on going northward the wooded areas gradually increase until forest predominates over prairie. In the neighbourhood of the brine

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springs the ground is barren of vegetation and numerous small saline lakes and ponds appear here and there. On other parts of the prairie, grass grows in abundance, affording splendid feed for cattle and horses, and indeed the latter animals are never housed, but roam over the prairie all winter and are in splendid condition by the spring.

Trips were made into the interior in several places on both sides of the river and particularly on the west side to examine the nature and occurrence of the sink-holes which appear on the sides and top of the escarpment. A description of these will be given further on. Sink-holes investigated.

The brine springs, which occur near the forks of the river and from which the Hudson's Bay Co. gets its supply of salt, were located and an observation for latitude taken to determine their position more accurately. Other brine springs were also discovered about six miles south-east of the forks. A much larger accumulation of salt occurs here, but on account of their being some distance from navigable waters, the salt from these springs has never been utilized. All these springs are situated along the base of the escarpment and at the time of our visit were nearly dry. They generally rise from among an accumulation of granite boulders and flow thence into shallow basins, where the water is evaporated, leaving a deposit of coarse salt. The stumps of trees, the boulders and the ground in the neighbourhood of the springs are all incrustated with the salt.

Fish are plentiful in the waters of Salt river, and the brine springs are a resort for moose and bear, which come there to lick the salt. Fish and game plentiful. A skull of a wood buffalo was also seen here, showing that these animals also frequented the neighbourhood, though none have been seen in the neighbourhood for some years.

We returned to Fort Smith on July 9, and immediately set about making preparations for a trip overland with horses. It was the original intention to make this overland trip with a wagon or cart but I found that it would be useless to attempt it, as the only place where a cart could be used would be on the Salt plain and many miles of bush road would have to be cut to get there, and beyond that a trail would again have to be cut. So I abandoned the idea and took pack-horses instead, at the same time hiring another man to act as guide.

We again left Fort Smith on July 12, this time with pack horses, taking provisions for two weeks as well as an extra supply to leave in a cache on Little Buffalo river, for I contemplated a canoe trip up that stream later in the season.

Timber and
hay.

For the first 10 miles after leaving Fort Smith the trail runs in a general direction S. 25 W. magnetic, through a level or slightly rolling country, well wooded with poplar, spruce and Banksian pine, with occasional swamps in which large quantities of hay could be cut. Then the forest gradually shades off into open fertile prairie, which extends up to Salt river, the river itself being fringed with a dense growth of poplars and willows. The crossing of Salt river is made just below the second large branch of the stream, and is rather a risky undertaking, as the bed of the river consists of a soft tenacious clay which would easily mire a heavily laden pack-horse. We camped the first night out from Fort Smith at this crossing, getting our drinking water from a small pond on the south side of the river.

Hills marking
ancient face of
escarpment.

Our course from the crossing was S. 20° W. (mag.) leading straight towards a bay in the escarpment to the west. After passing through the belt of timber along the river bank, we again emerged into the prairie country which extends up to the base of the escarpment. This part of the prairie is not nearly so fertile as that east of the river, and although it is largely covered with grass, there are a number of white barren alkaline patches which increase in size as the escarpment is approached. The first branch of the Salt river is forded three miles from the crossing of the main stream. It is only about twelve feet wide, and one foot deep with a gravel and clay bottom, and the water is very salty to the taste. A number of rounded wooded hills, 20 to 60 feet high, were noticed near this place standing like islands on the prairie and generally surrounded on all sides by barren patches. These hills were probably at one time connected with the escarpment to the west, but being composed of harder strata than the rest have resisted the action of erosion which caused the escarpment to retreat to its present line, leaving them as residuals to mark the line at which the face of the escarpment once stood. Scattered here and there around the base of these hills are boulders of granite and other igneous rocks. An exposure of much weathered limestone was crossed on the prairie about two miles from the escarpment. As the base of this is approached the barren patches give place to small saline lakes and ponds, the neighbourhood of which is very boggy and marshy.

Sink-holes.

The trail mounts the escarpment to the right of a small fresh water creek which enters the Salt plain through a narrow wooded valley and joins the first branch of the Salt river. From the top of the escarpment the trail runs three miles and a half through a very broken hilly country, timbered with poplar and Banksian pine; the roughness being due to numerous large deep sink-holes. The deepest of these would be about 50 feet. No exposures of rock were seen on their

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sides which were all covered with a considerable depth of light-coloured sandy waste. Just beyond these we entered an area of burnt rolling country which extends for 3 miles along the trail. This area had been burnt probably 25 years ago and is now covered with a thick growth of young Banksian pines.

Leaving this burnt area, a short steep descent is made in low swampy land with several muskegs. It is only in these muskegs that any deep moss is seen, the greater part of the country being dry with little or no covering of moss.

Gradually again going south-westward the country becomes more open and dry until after about four miles we get into what the natives call prairie, but it is really only a succession of small prairie openings, few of which are more than 150 yards long. We travelled through this for about five miles and seemed to be going diagonally across it. The prairie itself runs nearly north and south. It is said to continue with frequent interruptions nearly as far down as Great Slave lake, running parallel with the Little Buffalo river and on both sides of it. It is in this open country that the wood buffalo are to be found. While making a camp on the shore of Flat Grass lake we disturbed a small band of ten or twelve of these animals, but we were unfortunate in not getting a sight of them. Although they are protected by law they do not seem to be increasing as fast as they should. The Indians are very careful now that none should be killed by hunters; but are not so particular in protecting them from the timber wolves, which are the cause of the lack of increase. A full-grown animal can easily take care of itself, but the young buffalo fall an easy prey to wolves. If some inducement were offered the natives for the killing of timber wolves there would be a greater increase in the number of the buffalo.

Flat Grass lake lies about half-way across the so-called prairie and is a shallow marshy lake a mile and a half long by half a mile wide. The shores are covered for fifty or sixty yards with thick grass. Ducks were plentiful in the lake. Many ripe strawberries were seen on its shores.

Four miles and a half from Flat Grass lake the trail strikes Little Buffalo river, which is here about 25 feet wide with a good current, and many large boulders in its bed, which form small rapids at various points. The trail follows the east bank for another five miles through a thickly wooded country, the greater part of which had been burnt, probably twenty years ago. A crossing is then made to the west side of the river at a point where the water is only about eight

inches deep and very rapid. For about twelve miles the trail then follows the west bank of the stream, touching it here and there, but frequently being a mile or more away from it.

Here also the country had nearly all been burnt at the same time as that on the east side. The trail on the west side is seldom used in summer and runs through a very swampy country, occasionally rising on to narrow sandy ridges, wooded with poplar and Banksian pine. Some distance ahead could be seen a low range of hills running nearly true north and south and where the Little Buffalo river cuts through these, a second crossing is made back to the east, or locally the south side. These hills are known to the Indians by the name of Nini-Shith, or fallen tree hills; so called on account of the great number of fallen trees upon them. Their highest points do not exceed 150 feet, and where the river cuts through them, they are seen to consist entirely of sand. To the south-east they could be seen stretching away for eight or ten miles in a series of high rounded hills connected with each other by lower ridges. To the north-west all the ridges seem to be merged into one much broader than the rest.

On the east side of the river we were still in burnt country and I may say, that this area extends for a distance of 25 or 30 miles from north-east to south-west and runs as far to the north-west and south-east as could be seen from the top of the hills.

Cariboo
mountain.

About six miles beyond the second crossing of the river, we ascended a ridge, 100 feet high and followed this in a south-easterly direction for nearly three miles. The ridge is very steep and narrow, resembling a moraine, and is composed entirely of sand, and from its highest point a good view of the country was had. To the south-west, Cariboo mountain could be seen on the horizon, looking blue in the distance, and about five miles away stretched another ridge almost parallel to the one we were on and hiding the view between that and Cariboo mountain. To the north-west could be seen the shallow valley of the Little Buffalo and to the east five or six miles away, another ridge parallel to this one and higher in a good many places. Between the two ridges lay a large muskeg, mostly dry, but here and there showing small gleaming patches of water. Judging by the shells on the muskeg, the whole must have been covered with water at no very remote period.

Since crossing the Little Buffalo river the last time, we had been following no trail at all, but on the top of the ridge, we found an old buffalo trail, and had fairly good going to the end of the ridge. Old buffalo wallows were also numerous on its top.

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Leaving this we descended to a muskeg, where we had great difficulty with the horses on account of the boggy nature of the ground. In several places the moss is dry and thick, and a fine black powdery dust rises behind the moving animals. The muskeg is treeless, except for a few small stunted spruces.

On crossing the muskeg the land begins to slope almost imperceptibly up to a height of 80 feet, and on the northern slope of the hill there is as fine a growth of spruce and poplar as I have seen north of the Peace river. Spruce trees 26 inches in diameter and poplars 18 to 20 inches are common. There is no underbrush, and the ground is covered with about four inches of soft moss, the whole having a park-like appearance. On the top of the hill the timber becomes much smaller and the growth thicker, so that we had some difficulty in forcing a way through.

Fine spruce
and poplar.

Three miles beyond this last ridge we crossed another, but not before making a great detour to avoid Brabant lake, which is about two miles long by half a mile wide, and without any outlet. Descending into the next valley, we passed Loon lake on the west side and about a mile beyond it reached the shore of a large lake called by the Indians Moose lake. This is a beautiful sheet of water about eight miles long from east to west, and about four miles wide. A small creek flows from the west end into the Little Buffalo river, but it is not navigable and the Indians usually carry their canoes across a portage to get into the lake.

I had hoped to be able to reach the Cariboo mountain, but I now saw that it would be impossible to do so with horses as there is no trail, and the country is practically a huge muskeg up to the base of the mountain. So after sketching in the shores of Moose lake I was reluctantly compelled to return to Fort Smith, arriving there on July 22, after having been away 11 days. At Fort Smith I gathered as much information as possible about the canoe route from hence to the Peace river via the Little Buffalo and Jackfish rivers. Very few of the Indians had ever been over it, and then only during high water in the spring, and these doubted whether it could be followed at this season of the year, and advised me to go in a small birch-bark hunting canoe. To hire a guide for the whole trip was impossible for several reasons, one of which was that an epidemic of sickness had visited Fort Smith and nearly every able-bodied Indian was laid up; so I had to content myself with a rough sketch of the route, supplemented by a good deal of inaccurate information. On the 2nd of August I started again with Mackay, for the last time from Fort Smith.

Return to
Fort Smith.

Going down to the mouth of the Salt river, we camped there and succeeded in inducing an old Indian to go with us as far up the Little Buffalo river as the point at which the summer trail first strikes it. Although he was a man about 60 years of age and could not do much work, his knowledge of the route saved us a good deal of time, particularly in finding the portage.

Ascend Little
Buffalo river.

Leaving the mouth of Salt river we again ascended that stream for twelve miles before coming to the trail leading to the Little Buffalo river. A short portage of some 30 yards is first made into a little pond about 100 yards long, and from it the trail mounts a small rise of twenty feet and enters a fine country sparsely wooded with poplar and green alder. This kind of country continues for half a mile when the trail runs into an open prairie, stretching nearly to the Little Buffalo river. This is part of the Salt plain, and like the other parts, is broken here and there by strips of timber. The total length of the portage is nearly seven miles and its general direction S. 70° W. (mag.) About a mile to the south of the portage trail is a continuation of the escarpment mentioned before, which here runs parallel with the trail; but after crossing the Little Buffalo river it bends more to the north and seems to decrease slightly in height. Exposures of limestone can be seen in several places along its face. Along its base are a number of small saline lakes and here and there barren alkaline patches occur. As a rule, however, the prairie is covered with a luxuriant growth of tall grass. The great difficulty in traversing the portage is the scarcity of drinking water, and the only place where this could be obtained was a small pond three-quarters of a mile north of our camp of Aug. 4. From this point to near the Little Buffalo river, water had to be carried, as that of the Lop-stick creek itself is not fit to drink. In a season of greater rainfall, however, there would not be the same difficulty. For the last three miles the trail runs through very wet and boggy country, but the water in the numerous ponds is always salty.

Drinking
water scarce.

Lop-stick
creek.

The portage ends in Lop-stick creek, which is not more than 10 feet wide and exceedingly crooked. It is so called because of a tall lop-stick, standing on its bank, which marks the point at which the trail strikes the creek, and which can be seen for a distance of two miles.

Like the Salt river, Lop-stick creek is fed from springs along the base of the escarpment and the water is consequently salty in taste and has a bluish colour, while the bed of the creek is covered with a thick green moss. To the south the course of the stream can be traced by a line of spruce and willows, and it empties into the Little

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Buffalo river about two miles north-west of the portage. At the time we went through, the creek as well as the ponds on either side were teeming with ducks.

At the junction of the Lop-stick creek with the Little Buffalo river, the latter is about 60 feet wide with little or no current. The water is deep but not clear. The banks, about four feet high, are well wooded with spruce and willow, with a good deal of swamp grass near the water. The Little Buffalo river empties into Great Slave lake a few miles west of Fort Resolution, and is frequently used in the early spring as a canoe-route from Fort Resolution to Fort Smith, as it breaks up earlier than the Slave river. It has been explored as far up as the Salt river portage, but hitherto no explorer has been beyond this point. We were soon made aware of this fact by finding at short intervals huge trees lying across from one bank to the other, all of which had to be cut out to permit a passage for the canoe. The water of the river is not very good to drink, but still it is much better than that of the Lop-stick creek.

Description of
Little Buffalo
river.

The course of the river above the Lop-stick creek is slightly east of south up to the base of the escarpment, when it bends more to the west, and it is exceedingly crooked. Exposures of limestone are first seen where the river emerges from the higher land, and here also is a cliff of impure gypsum ten feet high at the base of the escarpment. The height of the banks soon increases to sixty or seventy feet and the current becomes much swifter. Short shallow rapids are formed here and there, either by accumulations of boulders or as a result of the work of beavers.

For six and a half miles above the first exposure of limestone, or as far up as the falls, the valley of the river much resembles a gorge. It averages about 150 yards in width and is altogether out of proportion to the size and volume of the stream, which is only about forty feet wide. The sides are nearly vertical walls of horizontal limestone from seventy to 100 feet in height; and in places where I climbed to the top of these cliffs, I found that the country above and behind them was much cut up with deep sink-holes, in some of which the solid rock was exposed, but as in the case of those seen earlier in the season, the majority of them were lined with debris. The timber here consisted largely of poplar, and in the valley I noticed balsam fir for the first time. Gooseberries, raspberries and saskatoons were seen in great abundance.

Valley
resembles a
gorge.

Half a mile below the falls the river becomes too shallow and rapid for canoe navigation, and here a portage of three-quarters of a mile is

Falls.

made on the east bank. The trail runs through a broken hilly country wooded entirely with poplars and willows : and the difference in elevation between north and south end is nearly 100. The river itself makes a bend from the lower end of the portage, first to the south-west and then to the east, and about half-way round this bend are the falls, while above and below for some distance are a series of shallow rapids, the lower ones filled with sharp angular boulders of limestone, and the upper with rounded boulders of igneous origin. There are three separate falls, the lower one being much the greatest. In this one there is a sheer drop of forty feet over the limestone, the upper stratum of which is harder and more resistant than the lower, and consequently the upper overhangs slightly, so that it is possible to walk across the river between the falling water and the cliff, but not without getting wet from the spray. The volume of water falling over was small and its width only about twenty-five feet. There is a deep basin at the foot of the falls almost completely surrounded by vertical walls of limestone 100 feet in height. The middle fall is 100 yards above the lowest and had a drop of about sixteen feet in nearly twice the horizontal distance. It is a more beautiful sight than the other, as it has the form of a crescent and the water falls over thin beds of limestone in a series of short steps. The upper fall is about seventy-five yards above the middle one and has a drop of only five feet. Above this there are shallow rapids as far as the end of the portage. The gorge below the falls measures the distance those falls have receded from the face of the escarpment since the genesis of this part of the river, and shows it to be about six and a half miles. Samples of the limestone and some fossils were collected from this place.

Beaver dams.

Soon after leaving the falls the course of the river turns towards the west and continues in this direction for three miles, when it again bends gradually towards the south, and twelve miles farther on, towards the south-east. There is little of interest to distinguish one part of the river from another and as far up as the summer trail there is merely a succession of shallow rapids, dead water and log jams. A few short portages were made to avoid log jams, the longest of these being 300 yards. Beaver dams were also very numerous, but only the larger new ones were noted. The width of the stream above the falls averages about thirty feet and the banks are usually about four feet high, fringed with grass. The prevailing forest tree is spruce, but tall willows frequently form an archway over the stream.

Four miles south of our camp of August 8, we entered an area of country which had been burnt about twenty years ago. This extends

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on both sides of the river, for about ten miles, and it is here that many of the log jams occur.

A winter trail from Fort Smith to Bog lake crosses the river about seven miles north-west of the summer trail, and this trail also crosses the Salt river at the forks. It was near this winter trail that on August 11 our old guide turned back, and from here on we had to find our way merely by the aid of a rough map that he made for us.

From the summer trail up to the Nini-shith hills the course of the river is about S. 30° W. magnetic, and it varies little in general character. The valley is generally half a mile wide and only about 25 feet deep, while the adjoining country on either side is a thickly forested, level or gently rolling plain. The only creek of any size entering in this stretch is Sucker creek, flowing in from the east about three miles above the first crossing. It is about thirty feet wide at the junction, but with no current and very little depth of water. Beaver dams are numerous, and shallow rapids are met at nearly every turn, in one of which the bed was seen to be composed of limestone. The country on both sides has here also been burnt, but no log jams occur, as the river is almost entirely fringed with tall willows.

After passing through the Nini-shith hills the course of the river is nearly west for about six miles, where at the entrance of a small creek from the north it turns sharply to the south again. There is a strong current all the way, but no rapids. The bed of the river is covered with grass and has no boulders. It is probable that the boulders in the river below the Nini-shith hills come from these hills, but in the cut banks none could be seen. Areas of good hay are frequent in the valley of the river, which is from 200 yards to a quarter of a mile wide, and in a few places that had been untouched by fire, spruce trees, up to twenty inches in diameter can be seen, but there is no birch or balsam.

At our camp of August 13 the valley of the river is much narrower and the course of the stream is south, gradually bending to the south-east as it approaches a high wooded ridge running east and west. Where the river meets the ridge, cut sand banks 25 and 30 feet high are seen. About half-way down the last stretch, a small creek enters from the west, and on following it up for about 300 yards, I found that it was highly sulphurated, and a strong odour of sulphureted hydrogen sulphide was given off when the moss in the bed of the creek was disturbed. The creek rises in a small pond 40 yards across, and although the water is beautifully clear and the bottom everywhere

Sulphur
spring.

visible, I could not locate the exact position of the spring which is the source of supply. The taste of the water was distinctly sulphurous and the moss and stumps in the bed of the creek were covered with a white coating.

In its course through the ridge mentioned above, the river becomes very shallow and rapid, and sharp angular boulders of limestone are frequently seen, but no rock in situ. In these rapids on account of the difficulty of cutting out portages, we found it quicker to remove the boulders from the channel and make passages for the canoe. It took us the greater part of a day to get through these rapids, though they only extended for three miles.

Portage route
to Moose lake.

A small creek enters from the east just above these rapids, and near the mouth of the creek we found the trail over which the Indians portage their canoes to Moose lake.

Above the Moose lake trail the river widens to 50 feet and we passed a number of beaver dams; but instead of being a hindrance to us, they were a great help by raising the level of the water above them. These dams were generally about two feet high and well constructed with stones and willow brush.

After passing through another low wooded ridge, in which we again encountered a number of rapids, we entered a low swampy country where the river widens to 100 feet or more. Moose creek enters from the south, just above these rapids, and at this point the Little Buffalo river takes a sharp bend to the north-west. Following this course for three miles, we enter a small marshy lake half a mile long and about the same in width. We leave this lake half way down the south shore and in a little more than half a mile enter a larger lake. Both of these lakes are shallow, and the bottom of each is covered with a soft slimy mud, into which a paddle can easily be thrust three or four feet. The shores of the lakes are covered with grass and willows.

The river enters the second lake about half a mile from its outlet on the west side, and a short distance up becomes very difficult to navigate, for the willows from either bank meet in the centre and completely block the passage. The banks are about 2 feet high and are continually caving in so that the stream has to cut new channels for itself.

Bog lake

Three miles above the lake we reached the forks of the river, the left branch coming from a large lake one-third of a mile to the west. The Indians call this Thul-tue or Bog lake. Its length was estimated

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to be about eight or nine miles and its greatest width lying about nearly north and south. It contains plenty of fish and is a favourite winter resort for the Indians trading at Fort Smith. At one time the lake probably extended over all of the river valley as far down as the last mentioned rapids, for the whole of this part lies in a well defined valley and is still very wet and marshy and covered with swamp grass and willows, while the river is confined to its present bed only by a low narrow rise on either bank, and behind this it is very boggy and marshy and rather dangerous for walking. The deepening of the channel at these rapids, however, caused the water to drain off, lowering the lake to its present level and shore line. The water of the Thul-tue branch is very muddy, while that of the main stream is clear and amber-coloured.

Half a mile above the forks a small stream eight feet wide with a strong current enters from the south-east, and this we at first took to be the right stream to follow; but on going up a quarter of a mile found it too narrow and crooked for the canoe. I have since learned that this creek rises in a large lake to the south-east, from which a portage is made into the Jackfish river. The other stream, judging by the width of its bed, is the main stream, but on ascending it for half a mile we found it almost dry; that is to say, where the water broke through an old beaver dam, it was only a few inches wide. According to our Indian map this was undoubtedly the right stream to follow, so on the morning of August 18, we made a long portage to avoid a succession of old beaver dams until we came to a large new dam, above which we found plenty of water and good paddling. In this part of the river, new dams are built nearly every year, each one a short distance above the one of the previous year, until for a distance of two miles and a half there is a series of dams at intervals of 50 or 100 yards. Beaver dams frequent.

Three miles above the last new beaver dam we entered a small muskeg lake* about one mile long. North, east and west of this the country is an immense muskeg, while to the south is a low wooded ridge of poplar, spruce and Banksian pine. The muskeg as well as parts of the ridge had been burnt years ago.

We leave the lake half-way down the west side, and after going westerly for three miles, the stream suddenly contracts to a width of a few feet and is so blocked with willows that we were unable to force a way through for the canoe.

At this place we spent half a day searching for the portage trail to Jackfish river, and finding none decided to cut one for ourselves. The distance across is only four miles and a half, but it took us two Cut portage trail to Jackfish river.

* Marsh.

days to make the portage. Cariboo mountain could be seen to the south and taking a course S. 10° W. magnetic, we made straight for three rounded peaks that could be seen on the top of the mountain. Our trail for the first three miles took us through burnt open muskeg, with several boulder ridges covered by poplar and pine which constitute the height of land between the Little Buffalo and Jackfish rivers. The last mile and a half lay through swamps and muskegs; and over the whole trail not a great deal of cutting had to be done except at the Jackfish river, which is fringed with a dense growth of spruces, alders and willows. We got everything over to the Jackfish river on the afternoon of August 21, and the same evening started down stream.

Topography.

Where we first saw the Jackfish river it is 40 or 50 feet wide with a sluggish current and very muddy water. Its banks are of clay and about five feet high, fringed with grass and wooded with fine large spruces, some of which are 30 inches in diameter, and like the Little Buffalo river, log jams are of common occurrence. The river runs parallel with the Cariboo mountain, which can be seen, eight or ten miles to the south-west, rising with a long gentle slope to a height of perhaps 1,500 to 2,000 feet above the level of the plain. The valley is very wide and shallow, occupied largely by open muskegs, and through it the river meanders in a very sinuous course. We took seven days in going down to the Peace river, though when the river is in flood it can be done in three days.

The general course of the Jackfish river from the portage down to Jackfish lake is about south-east. It resembles the Little Buffalo river in the frequency with which shallow rapids, log jams, and beaver dams occur; the rapids here also being formed by accumulations of boulders of granite and other igneous rocks. Hay may be obtained in large quantities in the swamps near Jackfish lake.

Jackfish lake.

Jackfish lake, through which the river runs, is a narrow sheet of water measuring about four miles in length, the south end of which approaches much nearer to Cariboo mountain than any part of the river. The shores are usually grassy, but in several places gravel and boulders are seen. The outlet is about half way down the east arm on the north side, where the river is about 100 feet wide and the banks hardly rise above the water.

For fifteen miles below Jackfish lake the course of the river is slightly north of east, running through a low swampy country wooded with spruce and willow, and in which a few low mounds rise above the level of the plain. As we approached the end of this reach the

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banks gradually became higher and the current much swifter, until we again got into a succession of rapids, where gravel banks were first seen. Passing through these rapids the river takes a sharp bend to the south and for the next ten miles the only obstructions to navigation are the log jams. Hills 150 feet in height rise on either side of the river, and soon after passing through these, we again entered a series of shallow rapids, none of which were bad enough to compel us to portage, but several were too shallow to run.

We were delayed at our camp of August 23 by rain, and soon after leaving it we entered a shallow grassy expansion of the river. This in the early spring or in a season of high water would be a lake three miles long by one mile wide, but was now almost dry. A mile and a half below this we passed the mouth of Berry creek, a very muddy stream thirty feet wide which joins the Jackfish river from the west. From thence to Gravel creek, a distance of about seven miles, the current is very slack and the river frequently choked with driftwood.

Gravel creek enters from the west, but unlike Berry creek, it is a clear water stream about fifty feet wide. It flows with a strong current and has a fine gravel bed. The bar at the mouth was prospected, but no indication of gold could be found. Below Gravel creek the Jackfish becomes very rapid and turns more towards the east; cut banks alternating with long sandy points; and ten miles below a portage of ninety paces is made across a point on the left hand side to avoid a big log jam. A mile and a half below this a second portage of 780 paces is made on the same side. Here we were led to suppose that the river ran underground, and although it does not actually do so, the huge pile of driftwood that has collected and lain there for years has become so filled in with sand and mud that it looks as if the river did run underground, and one can walk across dryshod. The same thing occurs again some three miles below where another portage 180 paces in length is made on the right hand bank of the river. These three portages are the only ones that have to be made in going down with the high water.

The banks in the neighbourhood of the portages are about ten feet high and are everywhere wooded with fine large spruce, but about ten miles below, the river cuts into a sand bank forty feet high. From the top of this the country on both sides of the river is seen to be very flat with few rises. It is thickly wooded and the only openings to be seen are swamps. Below the cut sand-bank for about 15 miles the current is not strong and the river is very crooked; then we entered a long succession of rapids which continue for nearly 20 miles. The river in these rapids

passes between high hills wooded with poplar and Banksian pine, and we frequently saw cut banks of gravel or clay. Most of the rapids were navigable, as the volume of the water was considerably increased by the two large tributaries mentioned above. Near the end of these rapids I noticed several sulphur springs resembling those on the Little Buffalo river.

From this point to the Peace river the course of the stream is slightly north of east and is very crooked. No more rapids or log jams are met with, and the river winds through a deep wooded valley in which spruce is the prevailing forest tree. As the Peace river is approached, however, the valley widens to about half a mile, and the spruce is replaced almost entirely by poplars and particularly the balsam poplar.

Mouth of
Jackfish river.

We reached the mouth of the Jackfish river on August 27, hoping to find some Indians there, but, although there are a few houses, some on each side of the stream, they were all unoccupied at the time. The Jackfish river is here nearly 50 yards wide, without visible current, and it enters the Peace river, as near as I could judge, about 15 miles above the rapids at Peace point and about 130 miles below Little Red river post.

From the mouth of the Jackfish we had the choice of two routes out to Edmonton, and selected the one *via* Peace river and Lesser Slave lake, as being the easier. So, after taking bearings on all prominent points in its neighbourhood, I closed my track-survey and left the Jackfish river on August 28 for Edmonton, reaching that place on October 9 and Winnipeg on October 13.

Acknowledg-
ments due.

My acknowledgments are due to the officers of the Hudson's Bay Company on the Slave and Peace rivers for much kindness and assistance, and particularly to Mr. Brabant, of Fort Smith, where I made my headquarters while exploring the district west of that point.

The topography of the country travelled over is very uniform and simple, and the most pronounced feature is the steep escarpment at the base of which the brine springs are situated. If a cross section were taken from Fort Smith south-west to Cariboo mountain it would show—first, the comparatively narrow level region bordering the Slave river, dipping very slightly as we get into the Salt plain, then the abrupt rise of over 200 feet to the top of the escarpment, much broken near its edge by numerous deep sink-holes. Beyond this an almost level upland stretching to the Nini-shith hills, which rise 100 feet above the general level of the plain; then going south-westward of

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these a gently undulating surface rising slightly to the height of land, then dipping again to the Jackfish river valley in which the stream has carved a smaller valley, then rising once more with a long easy slope to the Cariboo mountain.

With regard to the geology of the region, I may say that nearly the whole area is covered by rocks of Devonian age, though, as they are undisturbed and lie horizontally, it is only in a few places that exposures appear on the surface.

At La Butte, on the Slave river, 40 miles above Smith Landing, there is an outcrop of limestone associated with some gypsum and mineral tar; but no fossils were found by which it could be compared with the exposures in the escarpment at the brine springs; lithologically and in their associations with beds of gypsum they appear very similar. At Stone island also, about 25 miles below La Butte, limestone is exposed, and is here seen to rest directly on rocks of Archaean age.

The escarpment already mentioned near the brine springs was examined in several places. Its greatest height above the Salt river was found to be 210 feet, dropping to 150 at the Little Buffalo river, and its general direction about north-west and south-east. Three miles north of the forks of Salt river, where cliffs are exposed, they are seen to consist entirely of limestone, lying horizontally. But one mile south of the forks a bed of gypsum 20 feet thick is exposed near the base, and interbedded with this is a thin layer of red clay, while underlying the gypsum, and seen in the bed of the Salt river is a thick deposit of clay. Near here are the brine springs, but it was impossible to determine the source of the salt. Specimens of the limestone and gypsum were collected, as well as a few fossils from the cliffs north of the forks.

Deep sink-holes were mentioned as occurring in several places, and particularly where the summer trail mounts the escarpment, on the sides and top behind the brine springs, and also below the falls on Buffalo river. In only one or two of the smaller and more recent holes behind the brine springs was any rock exposed on the sides, and in these cases it was limestone. In all the others examined, because they were of earlier formation, the sides were covered with surface deposits, and sloped sharply down to a point in the centre resembling a funnel. Some were wooded to the bottom, particularly those on the Little Buffalo river. The majority of them were dry in July, but some of the larger and deeper ones contained fresh water, and these

Sink-holes
examined.

may be the source of supply for the brine springs, at the base of the escarpment. The amount of surface water has a very marked effect on the volume of the springs, and in the spring the flow is much greater than later in the summer. The sink-holes vary in depth from five feet to 50 feet or more. An isolated sink-hole 25 feet deep was seen along the trail near Flat Grass lake, and the broken nature of the surface here would seem to indicate it was underlaid by beds of gypsum.

Cliffs of limestone and impure gypsum.

Cliffs of impure gypsum ten feet high occur on the Little Buffalo river where it emerges from the face of the escarpment, and in the gorge above this we saw cliffs of massive limestone rising perpendicularly from the water to a height of 60 feet or more. Very thin beds of gypsum occur with the limestone and the rock lies horizontally and contain few fossils. At the foot of the falls the cliffs are 100 feet high. Here the lower beds are very thick and contain a good deal of gypsum scattered in crystals throughout the rock, consequently are very soft, while the upper strata are much harder and lie in thin beds. Crystals of iron pyrites occur in the upper strata.

On the floor of the Salt plain, three miles and a half south of the forks is an outcrop of limestone over which the summer trail passes. A specimen of this is submitted as showing the extent to which decomposition has gone. The whole outcrop is honeycombed, leaving only a skeleton of the harder parts. Another example of weathering is shown in the igneous boulders scattered over the clay flats in the vicinity of this outcrop of limestone. The boulders are generally of granite and are so much weathered around the base for about six inches up that they now resemble large mushrooms.

No exposures of the older rocks occur on the Jackfish river, though a few miles below the Sulphur springs large angular blocks of limestone are so common that the rock in places cannot be far beneath the surface. Recent deposits of sand and gravel however, are frequent in the lower part of the river. Exposures of clay occur just below the Sulphur springs and these are overlaid by about 20 feet of sand in which thin beds of peat occur.

Evidence of glacial action.

Evidences of glaciation in the form of numerous glacial erratics are everywhere visible, and particularly on the portage over the height of land between the Little Buffalo and Jackfish rivers. Nearly all of the rapids in each of these rivers are formed by accumulations of glacial boulders. No glacial striae, however, were seen on any of the exposures of limestone. The Nini-sheth hills are very probably eskers, and seem to have no definite regularity. They are composed of fine sand

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and have a general direction of nearly true north and south. On the north side of the Little Buffalo river they merge into one broad ridge, while on the south side they are split up into several rather sharp ridges, which again almost coalesce so as to inclose a large basin-shaped hollow, which was at one time occupied by water, but is now an almost dry muskeg. Similar smaller ridges occur on the Jackfish river about Jackfish lake.

NOTE.—All bearings mentioned in the above report are magnetic.

THE BLAIRMORE-FRANK COAL-FIELDS.

Mr. W. W. Leach.

The Blairmore-Frank coal-fields are situated a few miles east of the summit of Crows Nest Pass and are separated from the Crows Nest Coal-field proper by the main range of the Rocky mountains. To the south they are cut off by the Devonian-Carboniferous rocks of the Flathead range. To the north the limit of coal-bearing rocks is not as yet defined, but it is certain that it extends a considerable distance north of the present map. Eastward the belt of Lower Cretaceous coal-bearing rocks extends about fourteen miles from Crows Nest lake, when it is overlaid by rocks of Upper Cretaceous and Laramie age, also coal-bearing, but to a lesser extent. The accompanying map shows part of the latter formation.

Area of field-work.

The existence of valuable coal deposits in this district was noted by Dr. Dawson in his 'Report on the region in the vicinity of the Bow and Belly rivers (See Report of Progress, 1882-84, pages 101c. and 103c.); and again in his report on that portion of the Rocky Mts., between latitudes 49° and 51°30', (See Annual Report, 1885, pages 58B and 69B.)

Up to within the last two or three years very little had been done to exploit these fields, lack of transportation facilities being the chief drawback; the construction of the Crows Nest Branch of the Canadian Pacific Railway, however, crossing as it does the coal-bearing strata almost at right angles, has removed this difficulty; and within the past few years a great deal of work has been done, chiefly prospecting and surface stripping, so that it is now known that the productive coal measures are very much more extensive than was at first anticipated.

Prospecting.

This region, within the boundaries examined this year (viz: Tps. 7, 8, 9 and 10, R. 2, 3, 4 and 5 west of the 5th Meridian) is, roughly speaking, divided into almost equal parts by the Livingstone range.

General description.

To the west of this range and between it and the main range of the Rockies the country is somewhat rough and broken, and generally timbered. To the east of the Livingstone range the character of the country changes abruptly, the rough wooded hills giving place to low, rounded, grassy ridges, gradually decreasing in height until the open prairie valley of the Old Man river is reached. The Livingstone range itself is a rather remarkable anticlinal ridge, unbroken except where the Crows Nest and Old Man rivers have cut narrow gorge-like channels which are locally known as 'Gaps.' North of the 'Gap' of the Old Man river the range appears to continue for some miles. To the south, the Livingstone range (proper) ends at the Crows Nest river, although Bluff and Turtle mountains may be considered as a spur from the main range.

Direction of rocks. The general direction of the valleys and ridges throughout this area is north and south, coinciding with the strike of the rocks, and the Crows Nest and the upper part of the Old Man rivers cut the strata at nearly right angles.

Horizon of rocks. The rocks of this region may be divided into three main divisions, viz: the Devono-Carboniferous, the Middle and Lower Cretaceous, and the Upper Cretaceous, in which may possibly be included part of the Laramie; of these, the two latter are coal-bearing.

The Devono-Carboniferous rocks consist principally of limestone with some beds of quartzite towards the top.

Cretaceous. By far the most important series in this area from an economic standpoint, is the second division or Middle and Lower Cretaceous, which includes the principal coal seams. Wherever seen these beds appear conformable with the Upper Cretaceous and Laramie, so that until the country has been examined in greater detail and the fossils collected determined, it is impossible to draw a clearly defined line between this and the third division. For descriptive purposes, however, it will be assumed here that the volcanic intercalation, mentioned hereafter, represents the top of this second division.

Lower Cretaceous. The principal rocks in these beds in ascending order are as follows, the various thicknesses given being only approximate:—

1. Gray and black shales with a few thin arenaceous beds, 700 feet.

Thickness of divisions. 2. Productive coal measures, 740 feet.

3. Hard cherty conglomerate, in places replaced by very hard silicious sandstone, 30 feet.

1000 2 1000000

1000 1000000 1000000



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4. Light-coloured sandy shales and shaly sandstones with some characteristic dark greenish and purplish shaly sandstone and massive seal-brown weathering dolomitic sandstone. One thin bed of shaly limestone was noted in several widely separated localities and may prove of value as determining a definite horizon. Just below the volcanics, near Ma Butte, a bed of hard cherty conglomerate was seen; this was much finer grained than that occurring above the coal and was not noted elsewhere, 1,850 feet.

5. Volcanics, consisting essentially of a very important intercalation of volcanic ash rocks and agglomerates. They vary greatly in thickness, apparently attaining their greatest development between Ma Butte and the point where they cross the railway, about three miles and a half below Crows Nest lake, thinning out rapidly to the east. Their maximum thickness is probably not more than 1,500 feet.

These rocks were found of great value as forming a reference horizon for working out the faulting and folding of the region. They vary greatly in texture and in general appearance and may prove of considerable interest when examined under the microscope.

In comparing the Middle and Lower Cretaceous rocks of this area with those of the Crows Nest coal-field, a general similarity is at once seen, with, however, a very marked diminution in thickness in the rocks of this district. This is particularly noticeable in the case of the lower dark shales underlying the coal measures, which here represent the 'Fernie shales' of the Crows Nest field.

No attempt has been made to obtain a complete section of the rocks of the third division. Owing to their soft, readily-weathering nature, exposures are less frequent than in the lower beds, and especially to the east of the Livingstone range, they have been tremendously crumpled and contorted so that a great amount of detailed work will be required to obtain even an approximate section of them.

Immediately above the volcanics occurs a considerable thickness of gray and black shales, in places rusty-weathering, with at least two narrow beds of hard silicious sandstone. These are followed by an unknown, but probably great, thickness of soft light-coloured sandstones, varying in texture but generally rather coarse-grained. Towards the top these are interbedded with black and gray shales and at least two seams of coal.

The geological structure of this area is somewhat complex, much faulting and folding being in evidence. Following the line of railway

Middle
Cretaceous.

General
section along
railway.

across the map-sheet from west to east the section shown would be approximately as follows: About one mile west from the east end of Crows Nest lake the junction of the Devono-Carboniferous limestone, which forms the back bone of the main range of the Rockies, with the Upper Cretaceous beds, is met with. This contact is evidently a faulted one, the limestone dipping about 30° west while the Cretaceous sandstones and shales have irregular westerly dips at high angles. About two miles east of this point the dip flattens until the strata are nearly horizontal, but continuing in an easterly direction, westerly dips are again met with, gradually increasing to a maximum of about 30° . At a point about three miles and a half east of the lake the volcanics are crossed. These are underlain by sandstones and sandy shales to a point a short way west of the mouth of McGillivray creek, where the conglomerate and underlying coal measures are seen dipping west 30° . From the contact with the limestone to this point the series is evidently a regularly descending one. Near the mouth of McGillivray creek, however, an extensive fault occurs with eastern downthrow, since from here easterly to a point about half a mile west of Blairmore station the above series is repeated, the coal measures outcropping at this point, dipping about 60° to the west. Only one seam, the upper, has been discovered here, the lower seams apparently having been cut off by another fault with similar easterly downthrow. The beds overlying the coal measures follow with westerly dips to a point just east of Blairmore station where the coal measures are again met with. From the base of the coal measures to the contact with the Devono-Carboniferous limestone of Bluff and Turtle mountains the surface is covered, but is probably underlain by the lower dark shales seen elsewhere underlying the coal seams.

Bluff and
Turtle
mountains.

Bluff and Turtle mountains lie along the axis of what is probably a compressed anticline slightly overturned to the east, the Cretaceous rocks having been eroded away, leaving the underlying Devono-Carboniferous limestone exposed to within a short distance of Frank station, when the coal measures are again encountered dipping west at about 85° . Here, however, the thickness of strata between the conglomerate overlying the coal and the limestone is very much less than that seen elsewhere between the same beds, giving the impression that a fault exists at the contact of the limestone and the Cretaceous rocks.

Frank to
Byron creek.

From Frank eastward to near the mouth of Byron creek a rather wide flat syncline is crossed, the coal reappearing on the axis of a sharp anticline at this point. This is followed by another similar syncline and anticline, the coal, as before, just coming to the surface on the axis of the anticline. Still another syncline follows, the coal

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measures outcropping at the old Livingstone mine. A few hundred feet to the east of this old working a fault must occur with the usual easterly downthrow, the light-coloured soft sandstones of the upper beds appearing again. From this point to the eastern limit of the sheet these rocks continue, but are so much folded and crumpled that no attempt will be made to describe their attitude in detail. It may be mentioned, however, that coal seams were noted at two or three points, and are probably the same seams repeated by folding several times.

A section across the northern part of the map-sheet will show a considerable diversity from the above, though in general the main features are alike. Thus, between the main range and the Livingstone range a series of faults occur with uniform easterly downthrow and some large folds, usually more or less overturned to the east, resulting in almost invariable westerly dips. East of the Livingstone range a narrow strip of Lower Cretaceous rocks with some coal is found, followed by the Upper Cretaceous and Laramie rocks much disturbed; both the contact of the Devonian-Carboniferous limestone of the Livingstone range and the Lower Cretaceous to the east, and that between the Lower and Upper Cretaceous being faulted.

Two sections across the coal-bearing rocks were measured, one at least, that at Cat mountain, being fairly complete, although it is possible that other seams may occur below the last one noted.

Cat mountain is situated on the west flank of the Livingstone range, about one mile south-east of the junction of Racehorse and Daisy creeks. The results obtained are as follows, given in descending order:

	Feet. Inches.	
1. Hard cherty conglomerate.....	9	6
2. Shaly sandstone.....	9	3
3. Black shale.....	4	0
4. <i>Coal</i> (impure).....	8	6
5. Black and gray shale.....	24	0
6. Hard light sandstone.....	27	9
7. Gray and black shale.....	4	0
8. <i>Coal</i>	4	0
9. Sandstone.....	13	0
10. Gray shale.....	2	0
11. <i>Coal</i>	3	6
12. Gray shale.....	13	6
13. Sandstone.....	4	6
14. Black shale.....	1	0

Section across
northern
portion.

Section at Cat
mountain.

	Feet. Inches.	
15. <i>Coal</i>	3	6
16. Gray and black shale.....	24	0
17. <i>Coal</i>	8	9
18. Gray shale.....	1	0
19. <i>Coal</i>	10	0
20. Gray shale.....	2	6
21. <i>Coal</i>	2	6
22. Hard, light sandstone.....	65	0
23. Gray shale.....	8	9
24. <i>Coal</i>	5	9
25. Hard, light sandstone.....	52	0
26. Black shale.....	9	6
27. Sandstone.....	1	6
28. Gray shale.....	12	3
29. Sandstone.....	10	0
30. Gray shale.....	11	6
31. <i>Coal</i>	5	6
32. Sandstone with a little shale.....	44	6
33. <i>Coal</i>	15	3
34. Gray shale.....	9	0
35. <i>Coal</i>	6	9
36. Gray shale.....	3	9
37. Hard, light gray sandstone.....	41	0
38. Black and carbonaceous shale and some coal.....	8	0
39. Sandstone.....	1	6
40. Black and carbonaceous shale and some coal.....	14	0
41. Sandstone.....	2	0
42. Gray shale.....	8	0
43. Sandstone.....	2	0
44. Gray shale and ironstone bands.....	11	0
45. <i>Coal</i> (impure).....	4	0
46. Gray shale.....	23	0
47. Sandstone.....	2	0
48. <i>Coal</i>	5	6
49. Gray shale.....	5	0
50. <i>Coal</i>	6	3
51. Shale.....	0	6
52. <i>Coal</i>	9	9
53. Shale.....	1	0
54. <i>Coal</i> (impure).....	3	3
55. Gray shale.....	7	0

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	Feet.	Inches.
56. <i>Coal</i>	8	0
57. <i>Shale</i>	0	6
58. <i>Coal</i>	4	0
59. <i>Shale</i>	0	4
60. <i>Coal</i>	1	9
61. <i>Shale</i>	0	6
62. <i>Coal</i>	7	6
63. <i>Gray shale</i>	21	8
64. <i>Sandstone</i>	1	0
65. <i>Gray and black shale</i>	2	9
66. <i>Black and carbonaceous shale and some coal</i>	4	0
67. <i>Gray shale</i>	15	0
68. <i>Yellow-weathering sandstone</i>	1	3
69. <i>Gray shale</i>	10	0
70. <i>Hard grey sandstone</i>	16	0
71. <i>Coal</i>	1	3
72. <i>Gray shale</i>	5	0
73. <i>Sandstone</i>	45	0
74. <i>Black and gray shale</i>.....	..	..
Total.....	742	0
Total <i>coal</i>	125	3

The second or Byron creek section is probably not complete, the lower seams being wanting. Owing to the thick drift covering and the lateness of the season, it was found impossible to strip the surface any farther down. The section given below was measured on the east side of Byron creek near its head. As in the first section, the order is descending:—

	Feet.	Inches.
1. Hard light-coloured sandstone; light conglomerate in places.....	44	0
2. Gray and black shales, shaly sandstone and a little coal.....	26	3
3. Covered.....	11	6
4. Hard grey sandstone.....	2	9
5. Black shale.....	1	6
6. <i>Coal</i> (rather impure).....	9	9
7. Black and gray shale and covered.....	33	0
8. Hard light-coloured sandstone.....	16	0
9. Black and gray shale.....	8	0
10. <i>Coal</i>	5	6

	Feet. Inches.	
11. Gray shale and shaly sandstone and covered	60	0
12. <i>Coal</i>	8	0
13. Gray shale	1	9
14. <i>Coal</i>	9	0
15. Gray shale	14	0
16. Gray shale and covered	36	0
17. Gray shale	5	0
18. <i>Coal</i>	8	6
19. Gray shale	1	0
20. <i>Coal</i>	12	0
21. Gray and black shale and shaly sandstone	5	9
22. <i>Coal</i>	8	6
23. Gray and carbonaceous shale	1	6
24. <i>Coal</i>	3	3
25. Gray shale	0	6
26. <i>Coal</i> (partly shaly)	10	0
27. Gray shale and covered	29	6
28. <i>Coal</i>	16	0
29. Hard light gray sandstone	41	0
30. Covered	36	0
31. Sandstone	3	0
32. <i>Coal</i>	11	3
33. Sandstone .....	..	..
Total	479	9
Total <i>coal</i>	101	9

It will be noticed that very little resemblance exists between these two sections. Taking into consideration, however, the fact that the two points are nearly twenty-three miles apart, much uniformity was not to be expected. Owing to the kindness of Mr. H. T. Collett, the following partial section measured by him was obtained. These measurements were made on McGillivray ridge and are of special interest in connection with the two previous sections as showing the persistency of the coal seams throughout a large area. Mr. Collett's section is as follows, in descending order:—

	Feet.	Inches.
1. Conglomerate	20	0
2. <i>Coal</i>	2	6
3. Sandstone and shale	20	0
4. <i>Coal</i>	5	0
5. Shale	10	0
6. <i>Coal</i>	5	0

Section on
McGillivray
ridge.

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	Feet.	Inches.
7. Sandstone.....	48	0
8. Coal.....	25	0
9. Shale.....	2	0
10. Coal.....	13	0
11. Shale.....
Total	150	6
Total coal	50	6

No analyses have as yet been made of the samples of coal collected this year, and it is probable that the quality will be found to vary considerably in the coal from the various seams as well as in the coal from the same seams in different parts of the field. Generally speaking, however, the coal throughout the district is apparently of good quality, resembling very much in appearance that from the Crows Nest coal-fields. The following partial analyses of coal from the Gold creek collieries, kindly furnished by Mr. R. Green, may prove of interest :—

Analyses of
coals.

Moisture.	Volatile Combustible Matter.	Ash.
1. Not over one per cent	24	8
2. "	23	8
3. "	24	8.5
4. "	24	7.6
5. "	24	8.5

It will be seen from the above that this is a very fair bituminous coal. The following analyses by Dr. Hoffmann of this department are from specimens collected by Dr. Dawson in previous years :—

Locality.	Hydrosopic Water.	Volatile Combustible Matter.	Fixed Carbon.	Ash.
1. North-west branch Old Man river, 8 ft. seam	1.24	24.62	66.61	7.53
2. Old Man river, two miles below 'Gap,' 5 ft. seam....	1.75	19.99	58.49	19.86
3. Crows Nest river, two miles below falls (upper seam 3 ft.)	3.27	32.53	44.38	19.82
4. Crows Nest river, two miles below falls (lower seam 3 ft.)	2.36	40.66	47.78	9.20

(See Report of Progress, 1882-84, pages 33, 34 and 35*m* and Annual Report, 1885, page 93*m*).

Of the above analyses the first two are from coals of Lower Cretaceous age, while the latter two are from Laramie or Upper Cretaceous coals.

Canadian-American Coal and Coke Company.

The most highly developed property in this district is that of the Canadian-American Coal and Coke Company. This company is operating a mine near Frank on the east flank of Turtle mountain. The seam is the upper one of the series and varies from nine to twelve feet in thickness, dipping to the west at about 83° , the strata being here slightly overturned. At the time of my visit a main entry had been driven in on the seam a distance of 4,500 feet, in addition to which there are two other drifts, one above and the other below. This company has been producing coal for over a year and during the past summer their output has been about 500 tons a day: it is expected, however, that this output will be largely increased within a short time.

This coal is of excellent quality for steaming purposes and is largely used by the Canadian Pacific Railway Co. on their locomotives, though it is reported to be rather high in ash.

A block of six coke ovens was built but is not now in operation.

Gold creek collieries.

The Gold creek collieries, operated by the United Gold Fields of British Columbia, are situated on Gold creek about $3\frac{1}{2}$ miles above the town of Frank. A spur line of railway has just been built from the Crows Nest branch of the Canadian Pacific Railway to the mines. At the time of my visit no shipments had been made, the railway not then being completed, but development work was in progress, a main cross-cut tunnel having been driven a distance of 394 feet and a tippie being under construction. The following section of the main tunnel from the conglomerate to the end was kindly furnished by Mr. Caudron of the company:—

Section.	Feet. Inches.	
	Feet.	Inches.
1. Conglomerate.....	1	1
2. Sandstone.....	3	2
3. Conglomerate.....	6	5
4. Sandstone.....	21	8
5. Shale.....	2	0
6. Coal.....	0	6
7. Shale.....	0	3
8. Coal.....	1	5
9. Shale with a little coal.....	2	11
10. Sandstone.....	2	9

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	Feet.	Inches.
11. Shale	0	4
12. Thin-bedded sandstone	12	2
13. Gray shale	5	7
14. Coal	2	0
15. Shale	9	8
16. Sandstone	8	6
17. Shale	6	3
18. Coal	0	1
19. Shale	1	0
20. Sandstone	4	3
21. Shale	5	5
22. Coal	3	3
23. Shale	0	3
24. Coal	4	7
Total	96	6

Besides this the company are opening up several seams on both sides of the valley, about one mile and a-half above the main entry.

The valley of Gold creek here occupies the centre of a rather sharp syncline, the coal measures outcropping on either side, so that it is possible, by means of short cross-cut tunnels to attack the coal on both sides of the creek.

In this part of the district the coal measures appear to have suffered a considerable diminution in thickness, as will be seen by comparing the section above with those of Cat mountain and Byron creek. The coal, however, appears to be of excellent quality and the seams of good workable size.

This company has also done a large amount of prospecting on Grassy mountain, which lies directly north of Bluff mountain and forms the axis of the northern extension of the Turtle-Bluff mountain anticline. A great number of coal seams have been uncovered at this point, but, in all probability, in many cases these are the same seams repeated several times by sharp folding.

This company expects to construct a number of coke ovens during the coming year.

Outside of the workings of these two companies, the work done has been largely of a prospecting nature. Among others the Newport-Paulson property, situated on York creek about two miles above its mouth, on the most westerly outcrop of the coal measures, may be

mentioned. Three seams of $17\frac{1}{2}$, 12 and 8 feet thickness respectively have been opened up by short tunnels showing good coal in each case; the strata here dip about 35° to 40° west.

Lyon creek. Considerable work has been done by the Hastings Exploration Co. on Lyon creek, several large seams having been opened up. The tunnels, however, have caved in so that it was impossible to obtain a section here. These openings are on the same outcrop as are those on the Newport-Paulson property.

Blairmore. About half a mile north of the town of Blairmore Messrs. Proctor and Fishburn have driven a cross-cut tunnel cutting two seams, besides having done a good deal of surface stripping.

A wagon road was built last summer up Byron creek and a number of seams were uncovered near the head of the creek: the Byron creek section on another page will show the result obtained here.

Byron creek. On the McVittie-Leitch property, near the mouth of Byron creek, a number of seams have been uncovered by open cuts. The coal apparently outcrops here on the crest of a sharp anticline and it is probable that some of the seams are repeated.

Upper Cretaceous coals. The coals and lignites of the Upper Cretaceous and Laramie have been opened up in several places, chiefly to supply the local demand for domestic fuel. In most cases however, the highly contorted condition of the strata renders mining difficult and uncertain. The most important of these openings is on the Galbraith property, about two miles below the falls on the Crows Nest river, where small shipments are being made more or less regularly. A short distance below this, on the Holway property, a shaft has been sunk on what is probably one of the same seams. This is now abandoned. Several other openings were seen, two on the Old Man river and one at Livingstone. In all of these the work done has been on a very small scale, shipments having been made intermittently for local use.

As it is now proved without a doubt that very large deposits of coal exist in this area, and success in future mining operations will depend largely on the selection of the best available sites. In this connection several factors have to be taken into consideration, such as the quality of the coal, transportation facilities, the absence of faulting, and the altitude of the coal seams themselves; with regard to the latter, it is the general opinion among local mining men that, for the present at least, the coal below the level of the valleys cannot be profitably extracted in competition with that won by drifting into the mountain sides and requiring no hoisting or pumping machinery.

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The limestone of Bluff and Turtle mountains is now being utilized Limekilns. to a certain extent, several limekilns being in operation on both sides of the railway in the Crows Nest Gap. This rock is said to make a very good lime for building purposes.

Several sulphur springs were noted as occurring along the eastern Sulphur springs. flank of the Livingstone range near the contact of the limestone and the Cretaceous rocks. The most important of these is situated about one mile west of Frank, just south of the railway, where a sanatorium hotel has been erected.

In addition to the geological work done during the season, a topo- Topographic work. graphical survey was carried on by means of transit triangulation, panoramic sketches, and traverse of wagon roads, trails, etc. Enough information was obtained to compile a contoured map of the greater part of the area.

A number of fossils were collected, chiefly from the Upper Cretaceous Fossils. and Laramie beds, with a few from the lower dark shales and some fossil plants from the coal measures. None of these have as yet been determined.

During the past year a great deal of interest has been taken in the possible future development of iron industries both in this district and in British Columbia. In view of this, a flying trip was made to the Bull river iron deposits Bull river iron deposits. situated on the south-east side of Bull river, about ten miles north of Jaffray station on the Crows Nest branch, and at an elevation of about 3,000 feet above the valley.

The base of the mountain consists of Cambrian quartzites and altered argillites dipping at low angles to the east. Towards the top these are succeeded by dolomites, interbedded with highly altered argillites, apparently conformable with the lower beds and probably also of Cambrian age. In a number of these upper beds the original constituents have been replaced in varying degrees by hematite ore. The work done consists entirely of surface stripping and open cuts, more or less disconnected, so that until further work is done it is impossible to form an opinion as to the continuity of the ore in the several beds, nor was the source of the ore made clear, though it is certain that mineralization has taken place over a considerable area. The ore appears to be of good quality, though in places, somewhat silicious. The maximum thickness of clear ore seen was about five feet.

EASTERN ASSINIBOIA AND SOUTHERN MANITOBA.

Mr. D. B. Dowling.

Lignite of
Souris river
and Turtle
mountain.

The treeless areas of Assiniboia and Manitoba are fast filling up with settlers and, as the fuel supply is an important item in the well-being and permanency of settlement, an inquiry into the conditions and extent of the coal mining industry in these districts was thought advisable. The mining of lignite in the Souris valley is well established, but no examination, of this district has been made since 1880, when Dr. Selwyn superintended the putting down of several bore-holes to test the eastern limit of the deposit. In Manitoba coal seams had been found on the flank of the Turtle mountain, and mention of these was made in the Summary Report of this Department for 1890-91, but these were isolated instances and an endeavour to correlate the seams and outline their possible outcrop seemed of present importance.

Beside the examination of the coal-field of the Souris and Turtle mountain, inquiries were made relative to some other industries in Manitoba, such as the making of brick, cement and plaster. The report which follows contains a summary of the field operations for the season with some general notes on the extent and topography of the Turtle mountain coal field, illustrated by a contoured plan of the northern flank of this hill.

In pursuance of instructions I proceeded westward, arriving in Winnipeg June 7. Here I was joined by Mr. Fred. Bell who was to be my assistant for the season. At Brandon we obtained a team and light wagon, intending to drive through the district southward to the Turtle mountain and observe any outcrops of the rocks which are beneath the Laramie or Lignite Tertiary which forms the summit of this elevation. Owing to the wet state of the roads, after visiting some exposures in the vicinity of Souris, I determined to ship the outfit to Estevan where I learned the roads were in better condition. In this way I could make the examination of the Souris coal-field at first and later during the summer that in Manitoba to better advantage.

Explorations
near Estevan.

On our arrival in Estevan we had evidence of the influx of land seekers in the crowded state of the hotels and the activity of the land agents and those in the livery business. We established our camp in the valley below the town and spent two weeks in exploring the banks of the stream between Estevan and Roche Percée. While there the stream rose in flood and prevented our driving across, so that much of our work on the south side was performed on foot.

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With the railway levels as a base, elevations were obtained with aneroid barometers and a series of levels (with an 18-inch spirit level) were made across the valley at the coal mines below Roche Percée. These were connected with the railway levels at the latter station and also carried east as far as the site of the bore-hole of 1880, located on the south-east quarter of Section 6, Tp. 2, Range 5 west of the Second Meridian. Topographic work.

From heights thus obtained a contoured plan of the area examined was roughly prepared showing intervals of ten feet, and from this a model has since been constructed for the purpose of illustration.

The coal horizons were traced in almost continuous lines from Estevan eastward for 14 miles and along the valleys of the Souris and Short creek to the International boundary.

After having completed the mapping of the field and the measurement of all the natural sections, we drove eastward by the trail near the railway to the Turtle mountain, where, on August 4, I began running a series of instrumental levellings to determine the elevation of all the known occurrences of lignite and thus obtain some basis from which to correlate the seams and find the probable slope of the horizon. In this endeavour we levelled over 52 miles of roads, and by driving from these known points were able to determine by barometer in a satisfactory way the contour of a wide belt around the north flank of the hills. As natural exposures in this country are rare, much of our information was obtained from those residents who had in sinking wells touched or passed through seams of lignite. In the mountain itself very little information could be gained except in isolated cases, owing to the lack of settlement and scarcity of roads. A more detailed account of the information thus gained, illustrated by a contoured plan of the lower slope of the hill, is appended. North flank of Turtle mountain.

On September 8, I disbanded the party at Boissevain and sold our horses and wagon, intending to visit such other localities as could be reached by train.

A mantle of sand and gravel is found in varying thickness over the area formerly occupied by the extinct Lake Souris. This lake was called into existence at the close of the glacial period when the edge of the ice sheet had melted back to the latitude of the Tiger hills and in the hollow in its front had accumulated water from the melting ice. As the natural outlet was thus closed by the ice an overflow to the south-east resulted, and as the fall down the face of the Pembina mountain was very steep, the erosion was rapid and a deep channel Superficial deposits in southern Manitoba.

was soon scoured out which now forms the valley in which a small stream, the Pembina river, flows. No distinct traces of shore lines are noticeable along the face of the Turtle mountain, but terraces and irregular hills of gravel and sand are found which were probably shallow water deposits. Ridges of this nature were noticed north of Whitewater lake, indicating a rise which approximates in elevation the gravel and sand terraces of the lower flank of the mountain occurring at about the 1,700 feet level. In the road cutting south of Boissevain, gravel and sand deposits are found resting on boulder clay near the top of an isolated hill.

Eastward along the railway the Cretaceous shales begin to appear in the beds of creeks crossed. At first, the shale exposed seems not to be in place but washed from the boulder clay, as, at the creek crossing between Ninga and Killarney, they were searched for but, although the cutting shows plenty of the gray shale, it is on the surface and has been washed out. The first definite exposure is at Crystal City, where there is a very thin coating of till.

Exposures
from
Boissevain to
Larivière.

The following notes regarding exposures seen from the train are here added. From Boissevain to Ninga the railway runs in sight of the foot of the slope of the hills to the south, which consist principally of a broken terrace at about a mile south of the track. Just above Ninga there is a gravel pit. About two miles east of the latter station there are some hills north of the track which have the appearance of being dumps of gravel. At Killarney there is a series of ridges which appear to be of gravel. They run parallel to the sides of the narrow lake, one on each side, though the southern one seems to be on the south side of the White Mud river. The railway cutting at Holmfield shows boulder clay covered, at a mile east of the station, by gravel. At the river at Cartwright there are no exposures but the cutting shows gravel and a little shale, and a mile east of the river sand is exposed in a ballast pit. All over the strip between this and Clearwater there are many ridges which are bare of stones. These are possibly gravel or elevations left from the denudation of the underlying shales. At Mather the gravel deposits must be thin, as boulders show thickly on the surface and in the slough near the town. At Clearwater there are several exposures of shale in the river bed, but it is not seen in the railway cuttings and, as mentioned above, the first appearance near the surface is at Crystal City. All along the grade descending into the Pembina valley, good exposures of the shales of the upper part of Pembina mountain series as described by Dr. G. M. Dawson, are seen wherever excavations have been made for the railway. This shows the absence in the valley of any thickness of boulder clay and

Pembina
valley.

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is a proof that the removal of the rocks in forming the valley was after the deposition of the boulder clay.

The lower division of the shales of the Cretaceous is not so homogenous in composition, as it includes clay ironstone, rusty clay shales, and soft black clay shales, in which there are many fragments of fish remains and some carbonaceous matter. These beds outcrop lower down the valley and at the locality visited, on section 14, township 2, they formed nearly the whole of a small cliff on the western bank of the river.

The calcareous clays of the Niobrara division should be exposed in the lower part of this valley, but I was not able to obtain definite information as to the location of any exposures. Where the Canadian Northern Railway mounts the Pembina escarpment at Arnold, light yellowish calcareous clays probably of this horizon are exposed in a small ravine. Beneath are gray calcareous clays in which inoceramus and oyster shells, as well as a variety of fish remains, are common. These species are supposed to be characteristic of the Niobrara.

The Union Mining Co.'s plaster mill on Lake Manitoba at Gypsumville and the quarries situated ten miles to the northeast were visited by means of the company's steamer from Westbourne. A short visit was also made to the quarries at Stonewall, at the request of Dr. Whiteaves, to add if possible to our list of fossils from that locality. Several forms were obtained, among which appears a new species of coiled cephalopod. I desire to acknowledge the efficient aid I received from Mr. F. C. Bell in the instrumental work accomplished during the season.

I returned to Ottawa September 29.

CEMENT.

Mention has been made of the occurrence of rocks in the Pembina escarpment which are referred to the Niobrara. These are chiefly calcareous clays, as distinguished from the clays both above and below them in which there is hardly a trace of lime. The exposure at Arnold by comparison with the railway levels, is situated between 1,200 and 1,275 feet above tide and is continued northward on the Boyne river or its extension in the township to the north-west. On section 15, township 6, range 8, marlite and calcareous clays are found between 1,220 and 1,320 feet above tide near the extension of a new line from Carmen to Somerset. Below them on section 13 of the same township between 1,120 and 1,220 feet, clays without lime are found.

Cement in
Manitoba.

Niobrara
shales.

On the banks of the Assiniboine river directly north of Treherne, Mr. Tyrrell recognized the Niobrara at what is supposed to be a much lower horizon, as also the calcareous clays penetrated in the well boring at Morden. This may indicate a thickening of the formation and the introduction of a band of dark clay between the members of the upper part and the lower.

Cement works
at Arnold.

These deposits are of importance in a commercial sense as they contain nearly all the ingredients required for the composition of cement. At Arnold, the Manitoba Union Mining Co. have established a small plant for the manufacture of cement. Their kiln and grinding house are situated in the ravine and are at present making a common grade of cement from the lower gray beds which are mined by a tunnel. The experiments made by this firm point to the lack of a pure lime in the rock now used. In other localities the upper part of this formation has proven very rich in lime, and beds approximating the correct percentage will no doubt be found above those now used. Experimental briquettes with an added percentage of imported lime were tested at the time of my visit and went as high as 500 lbs. per square inch after three months in water. This would seem to approach the strength of average Portland cement.

Cement rocks.

The section of the rocks exposed here shows fifty feet of light-coloured clays, generally light yellow and brown near the upper part of the hill and gray or bluish-gray at the bottom of the exposure. Dark streaks in the upper yellow part suggest carbonaceous matter, but many of them are found to be of a dark, almost black, clay without lime. The average sample of the yellow beds compared with the bluish-gray of those in the mine, show, according to the subjoined note, a percentage of lime which seems very constant and the assumption is that this thickness of 50 feet exposed in the hill-side might with advantage be all used without the expense which mining one bed imposes. The beds in the mine appear very uniform in texture, but the burnt specimens show in a marked manner that the beds are made up of thin plates differing in composition. The suggestion then that the whole mass be puddled seems reasonable, and to the uniform mixture then could be added such other elements as may be needed. The burning would also be more uniform if the material were pressed into bricks of a common form instead of a varied assortment of fragments large and small as at first attempted.

From the laboratory of the Survey, contributed by Dr. G. C. Hoffmann :—

‘Memo. re results of examination of two specimens of shale from Arnold, Man., collected by D. B. Dowling, 1902.





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(a.) A dark bluish-gray shale, was found to contain:—Lime, 32·07 per cent, equivalent to carbonate of lime 57·27.

(b.) A brownish-yellow shale was found to contain :—Lime, 31·51 per cent, equivalent to carbonate of lime 56·27.

BRICK.

The clay generally spread over the surface beneath the soil has been utilized in many places to make a rough brick for domestic use. A finer grade both as to colour and finish is required and generally imported for the more pretentious buildings in the larger towns and cities. An effort to utilize the shales of the Pierre formation which are exposed in the higher part of the province is being made in the Pembina valley where a great thickness of the upper part of the formation is exposed in the sides of the valley. Shales of
Pembina
valley.

The shales of this upper part are of a light gray colour, in heavy beds which readily split up into thin sheets. No traces of fossils were observed and the rock seems to be wholly argillaceous with no calcite. At Lariviere, the station in the valley, a brick-making industry has been started. The shale is pulverized as it comes from the quarry and compressed in the dry form. These bricks are at once built into the kiln for burning. The plant with a complement of 17 men is capable of producing 30,000 bricks per day. This method of making brick from shale is in active operation in Pennsylvania and other states and it is expected that with some modification it will be a success here. The fuel used is a mixture of wood and lignite.

The shale of the Pierre formation is exposed in many localities both in Manitoba and the Territories. A sample of this from Souris, Manitoba, was tested in the Laboratory of the Survey and experimental bricks made which prove the fitness of the material. Dr. Hoffmann gives it as his opinion that they would make a good class of fire brick. The tests to which the material was subject are here given from the Report of Progress for the years 1880-82, p. 2 H ;— Shale from
Souris.

‘For the purpose of brick-making this material requires, agreeably with the present experience no admixture whatever. In the following experiments it was simply ground to powder—which it readily admits of—mixed into a stiff paste with water, well pugged and then the moulding of the bricks proceeded with. By employing the material in a fine state of division, and forming the bricks under pressure, an article of very close texture may be ensured. The bricks after having been thoroughly dried, were finally burned in the muffle Tests for brick
making.

of a cupelling furnace, at a full red heat. On examination they were found to have retained their form well, having neither warped nor cracked: they were firm and tough; the colour, a very pleasing one, may, perhaps, be best described as a very pale brownish-yellow. They were in no wise affected by protracted and repeated immersion in water.¹

Fire brick.

Other of these bricks were inserted in covered crucibles, and these latter placed in an air-furnace, the temperature of which was gradually raised, until, at the expiration of an hour, a white heat had been attained, at which temperature it was maintained for an additional two hours. On opening the crucible the bricks were found to have retained their original form intact, they had neither warped nor cracked, their edges remained perfectly sharp and showed no indication of having undergone even the most incipient fusion. Colour, a very pale reddish-brown.

'The foregoing experiments tend to show that this clay is well adapted for the manufacture of an excellent building brick, and further, lead to the inference, that it could also be advantageously employed for the manufacture of a good class of fire brick.'

PLASTER.

Plaster of
Paris.

The gypsum deposits at the base of the Devonian, as exposed north of Lake St. Martin, are being utilized for the making of plaster. The deposits are worked in open quarries and the gypsum transported to the shore of Lake Manitoba, where it is ground and burnt—shipment to the railway at Westbourne being made by steamer. As the gypsum deposits were first examined by Mr. J. B. Tyrrell in the summer of 1888, the description published by him in the Canadian Record of Science for April, 1889, might be here reproduced, as his general report contained but a passing remark. His visit was made on foot from Lake St. Martin and after passing through a somewhat level country a rough ridge situated on sections 13 and 23, Township 32, Range 9 west of Principal Meridian, was reached and the following extracts from the above paper begin his description at this point:—'Following the ridge, still in a north-westerly direction, for a mile, the surface becomes very rugged and irregular, being broken by deep pits with steeply sloping sides. In this rough country, gypsum may be seen in numerous outcrops, being usually soft and crumbling from the effects of weathering, but in some cases it is still quite hard. The height of the tops of the knolls in this hilly area is about thirty-five feet above the eastern level plain, or sixty feet above Lake St. Martin. The breadth of the hilly country was not de-

Gypsum
deposits east
of Lake
Manitoba.

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terminated, the Indian who accompanied us stated that it extended in a south-westerly direction, as far as a certain point on our journey of that day, which was about a mile and a half distant from where we were then standing, beyond which the level country began again.

In a north-westerly direction the ridge was followed for two miles further, to a rather conspicuous hill a short distance north of the Ninth Base Line in section 2, Township 33, Range 9 west of the Principal Meridian. In this distance it appeared to be broken through by considerable gaps in several places, but where it was well marked, it invariably showed the irregular surface so characteristic of country underlain by gypsum deposits. In many places small caves would extend in from the bottoms or sides of the pits, some of which held beautifully clear cold water.

This country is a famous winter hunting ground for the Indians, for in the autumn the bears retire to these caves, as being comfortable quarters in which to pass the time until the following spring, and many of them are killed every year. Around the mouths of several of the caves could be seen marks of the axe, where the hunter had been obliged to widen the entrance to the cave to be able to get into it to secure his prey. The thickness of the exposures of gypsum in these holes and caves was nowhere very great, ranging as a rule from three feet to six feet six inches, but in none of them was the total thickness of the deposit seen.

Indian hunting ground.

The hill at the furthest point to which the ridge was followed, rises as a rounded knob, twenty feet above its general level. This hill, like the others, appears to be composed of gypsum, as on its sides are holes extending down twenty feet below its top, in which beds of gypsum are well exposed.

In the north-west corner of Township 32, Range 8, west of the Principal Meridian, is a rounded hill rising thirty-five feet above the plain, its greatest length being about 600 feet, and its greatest breadth 150 feet. Its surface is overgrown with small canoe-birch. Two holes, each about eight feet deep, have been dug by prospectors in this hill. One at the top shows, below a foot of decomposed material, seven feet of hard, compact, white anhydrite or 'bull plaster,' exhibiting a more or less nodular structure, and breaking on the surface into small irregular fragments. Very little bedding can be detected in the mass. The other hole is in the side of the hill fifteen feet lower down, and shows on top two and a half feet of white clay, consisting of decomposed anhydrite, below which is five feet and a half of white nodular anhydrite, similar to that in the other hole. This gives a thickness,

almost certainly, of twenty-two feet of this rock and it is not improbable that the hill is entirely composed of it.

⁴ Again, just north of the Ninth Base Line and two miles east of the township corner, between Ranges 8 and 9, is a poplar-covered hill or ridge thirty feet high. In various places on this hill are exposures of snow-white gypsum, similar to what has been described above, showing in some cases a thickness of ten feet in one section. The most of it is massive or crypto-crystalline, and lies in regular beds which dip slightly towards the west. Some of the beds or layers however consist of beautifully crystalline clear colourless selenite, which is easily broken out in lamellar masses of considerable size. This is the mineral which, in the west, has been so often mistaken for mica.

Gypsum
deposits east
of Lake
Manitoba.

⁴ As far as examined the beds preserve a pretty constant character. Where they immediately underlie the surface, the country is very rough and hilly, and the prevailing poplar of the region is mixed with birch, or the spruce of the adjoining low-lying land is replaced by Banksian pine. The gypsum itself is generally very pure, of a dead white colour, and usually stratified in rather thin beds, which are either horizontal or dipping at a low angle. Among the massive beds, however, are many others, composed of crystals or crystal masses, in which the crystals usually stand transverse to the planes of bedding. Some plates could doubtless be obtained from the crystal-masses sufficiently clear for optical purposes. No anhydrite was seen mixed with the gypsum, but one of the hills, as above stated, appeared to be composed entirely of it. It is much harder and tougher than the gypsum or hydrated sulphate of lime, is considerably heavier, has a roughly nodular, rather than a distinctly stratified structure, and is of a decidedly bluish tint.

Quarries
opened.

The bedded character of the gypsum is well seen in the quarries opened by the company. The one first worked is probably on the ridge followed by Mr. Tyrrell, and is in or near section 13. In this a quarry 55 yards long has been opened and shows an average depth of ten feet. From this, judging by the cross section of the ends, there has been removed about 1,800 cubic feet of rock. Nearly another quarry not so well worked out, is about 40 yards long. Prospecting pits showing white anhydrite near the surface have not determined its depth, and, judging from the nodular and lenticular inclusions in the face of the quarry near, some of these prospecting holes may have touched some of the thin beds and do not necessarily preclude the presence of gypsum beneath. Other quarries are to be opened farther to the east and north.

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The western limit to the uneven country underlain by the gypsum Plaster mill appears to be bounded by a small stream flowing south into the north end of Partridge-crop lake. So that a distance of ten miles intervenes between the deposit and the mill on Lake Manitoba. The rock is quarried and transported to the mill over a bush road by team. The mill is situated in a small bay just to the north of Davis point, and the material is piled in close proximity. As the shipping season is confined to the summer, enough gypsum has to be hauled to the mill during the winter to meet the estimated output for the next year. The grinding and roasting is by the usual burr stone, and kettle and the shipments Output during this season, according to the manager, average 70 tons per week. This will probably be increased in the future.

As these beds belong to a horizon just below the Devonian, as in the Probable extension of beds. western Ontario peninsula and in New York state, outcrops should be looked for in the country south of this locality and east of Lake Manitoba. The ridges west of Shoal lake and Stonewall might be predicted as possibly having concealed beneath the surface covering some of the beds of this deposit. Evidence of their extension to the west is shown in the boring on Vermilion river made by the Manitoba Oil Company, where at a depth of 550 feet, gypsum with a thickness of 15 feet was struck.

THE SOURIS COAL MINES.

The mapping of this field and a more extended report could not be Souris coal mines. accomplished in time for insertion here, but a brief note is given.

In the vicinity of Estevan there are roughly three series of seams which are for convenience referred to as Upper, Middle and Lower seams. The Upper (4 ft.) seam is found all around Estevan at various shallow depths below the surface. It has been struck in many of the wells and Seams in Souris district. has been worked along the outcrop by farmers and others in many places as far east as opposite the site of the bore-hole of 1880 in range 5. The seam maintains the average thickness of 4 ft. over most of this area. Though the quality of the lignite is generally inferior to that in the lower seam, its accessibility and even thickness renders it the more useful for purely local purposes. The Middle seam which has been burnt in many of the outcrops in the vicinity of Estevan and near Roche Percée, thins out very much. A small remainder of it has been mined out in an isolated hill in the valley at Estevan, and the seam in the old Dominion mine west of the town was probably on either this or the Upper seam locally thickened to 6 feet.

The Lower seam is separated into several smaller ones by clay Lower seams. partings of various thicknesses and is mined both beneath the town

and eastward in the vicinity of Roche Percé. The quality is much better than in the upper ones and at the eastern end of the coal-field the clay partings have thinned out and eastward from the Hazzard mine, in which there is still a trace of the parting; in the Souris and Roche Percé mines there is a clear 8 feet seam of good lignite.

Output of
mines.

The mines in active operation here are under one management and the average output during the summer months amounted to about 100 tons daily. As the autumn approached this increased and for part of the time trebled the summer output.

Extension of
field north
and south.

The extension of the seams northward toward the Souris branch of the C. P. Ry., was this year tested by an independent company having interests in property between the river and Bienfait. Owing to difficulties in penetrating some of the ironstone bands above the Lower seam several of their bores had to be abandoned but enough was done to prove that over a large area, deep mining from the surface is feasible. Southward, the sections on Short creek and Souris river afford evidence of the continuation of workable seams to the Boundary line.

COAL IN THE DRIFT CLAY.

Coal in drift
at Souris.

At Souris, Manitoba, dark shales of Cretaceous age outcrop along the banks of the river near the town. About half a mile east, at the old rifle range, a very thin streak of coal had been found some years ago near the top of the formation but subsequent borings by the Manitoba government had proved that below this there was a great thickness of barren shale. Notwithstanding this, a few of the residents still had hopes of the ultimate discovery of coal in the vicinity and a farmer had commenced the construction of a tunnel into a mass of boulder clay. This probably was induced by the finding in the drift many small fragments of coal along with pebbles derived from a distant source. The man was persuaded to abandon the enterprise as the drift over a large part of the western part of Manitoba contains fragments of coal probably derived from the lowest member of the Cretaceous formation—the Dakota sandstone—which would outcrop along the foot of the Pembina and Riding mountain escarpment.

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NOTES TO ACCOMPANY A CONTOURED PLAN OF THE LOWER SLOPE OF
TURTLE MOUNTAIN, MANITOBA.*Mr. D. B. Dowling.*

Explorations of areas covered by Cretaceous and Tertiary rocks on the plains has established the general fact that very little disturbance is to be found in the eastern part as indicated by tilting or faulting, and that in a general way the series of beds remain very nearly horizontal. Where there are known outcrops of coal it would be most probable that its continuation would within certain limits be found along a line representing points of equal elevation.

In examining the outcrops along the slope of the Turtle mountain it is found that they are so meagre and few that an attempt to correlate the beds by such exposures would be hopeless. On the other hand, many of the residents have by well-boring obtained a certain amount of information relative to the underlying rocks which would, if supplemented by a knowledge of the orography of the district, be useful and might lead to some definite result in tracing seams throughout the district.

The map submitted is ruled to show intervals of 25 feet difference in elevation over the lower slope and 100 feet in the higher parts.

The notes submitted represent such information as it was possible to gain in the short time at our disposal.

The general character of such coal as was seen by us is very similar to that of the lignite which is now being used from the Souris field. It may prove not so homogeneous or compact but will undoubtedly be useful for local use. It probably will not stand very long or rough shipment. Housekeepers in Deloraine who had used the coal from the McArthur mine claim that it was equal to the Souris coal. Unfortunately no analyses are to hand by which to make comparison, but it may be assumed that the lignite will contain a high percentage of water and therefore slack on drying and it will be necessary to keep it stored in a closed bin or cellar.*

* NOTE.—An analysis of coal from the northern part of Dakota in the Turtle mountain shows the nature of a probably similar lignite. This is poorer in fixed carbon than that of the lower seams of the Souris field, but very similar to some of the upper ones.

Analysis by E. Whitfield:

Water.....	13.98
Volatile hydrocarbon.	40.81
Fixed carbon.....	36.90
Ash	8.31

100.00

—Bull. U. S. Geol. Surv. No. 27, p. 74.

The western slope of the Turtle mountain is considerably more abrupt than that to the north. From Goodlands, a station on the Waskada branch, a rise of 200 feet in three miles reaches the base of the steep slope of the mountain proper. To the south, the outline of the mountain follows a nearly north-and-south line, but as will be seen from the contours drawn on the accompanying plan, the lower slope is carried out more to the west and in places along the western edge of Township 1, Range 23, a narrow terrace is developed. It is beneath this terrace that the first coal seams found in the district are situated. Several streams that have their origin not far to the east of this terrace or come from a bay in the outline of the mountain, cut deep ravines where they issue from the edge of the terrace. A well dug in the bed of one of these ravines on Section 12, Township 1 Range 24, passed through several coal seams from which a running stream of water was obtained. This apparently, proved too wet to work, and another pit was sunk from higher ground about 150 yards to the north. From this, coal was raised by means of a farm engine and drawn to Deloraine in the winter by teams. This pit is known, locally as the Vaden mine and some notes on it were published by Dr. Selwyn in the Summary Report for 1890. In digging the well in the ravine, after passing through the surface deposits, a mass of broken coal five feet thick was passed through, but in the shaft for the mine this was not recorded, so that probably it was an accumulation of drift material derived from a small seam just above.

Section at
Vaden mine.

Tp. 1, R. 24.

The section as obtained by Dr. Selwyn shortly after the well was dug is given below, with the elevation of the base of each member as deduced from levellings taken this season.

	Feet.	Inches.	Feet.	Inches.
Surface of ground.....	0	0	1773	6
Surface deposit	3	0	1770	6
Dark clay.....	4	0	1766	6
Coal.....	5	6	1761	0
Clay shale.....	10	0	1751	0
Coal.....	3	6	1747	6
Sandy brown shale.....	6	0	1741	6
Soft whitish brown shale.....	2	0	1739	6
Sandy clay	6	0	1733	6
Coal.....	1	6	1732	0
Friable whitish brown sand.....	12	0	1720	0
Bored from bottom of shaft sandstone.....	20	0	1700	0

Of the pit at the old mine Dr. Selwyn writes: * The coal was struck at 40 feet, 4 feet 6 inches thick, then 12 feet of sandy shale and thin bands of iron ore; coal 1 foot 6 inches; then bored 35 feet through sandy shale; total 78 feet 6 inches.¹

* Summary Report, Geol. Surv. Can., 1890, p. 11A.

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The elevation of the ground at the mouth of the pit is 1,794 feet above the sea. How near this is to the original surface is hard to determine, but from the above section it would seem that at about 1,754 feet a seam of coal 4 feet 6 inches was struck, so that the bottom of this would be at 1,749 feet 6 inches as compared with 1,747 feet 6 inches of the section in the flowing well. The bottom of the lower coal seam, 1 foot 7 inches thick, would be at 1,736 feet as compared with that in the well at 1,732 feet. These variations are due to the uneven thicknesses of the sandy clays and sandstones which intervene. The boring carried from the bottom of the shaft was probably down to the same bed as in the well or near to the 1,700 foot level*. The following elevations were determined in this vicinity: Top of bank on road north-east of mine, 1,842 feet 5 inches; on road bridge near mine, 1,784 feet 7 inches; on same road below Croyden school, 1,809 feet 7 inches; at flowing well near mine, 1,773 feet 9 inches; in bed of stream west about 50 yards in the north-west quarter of this section, 1,753 feet 5 inches. A flowing well at the last of the above points was dug into some coal in the bed of the creek not more than two feet below the surface, and on the north bank a caved-in pit was reported to have been sunk for coal. Further inquiry elicited the fact that the first coal taken out in the district came from this pit. Mr. Herman Mentz, who lives on the south-east quarter of Sec. 22, Tp. 1, R. 24, had, before the Vaden mine was opened, taken ten tons of coal from this pit at a depth of ten feet, or about two feet below the bed of the stream. The seam was four feet thick and, Mr. Mentz thought, tilted slightly to the north. If the bed was two feet below the bottom of the creek the elevation would be 1,751 feet, and it is probably the same seam as that in the mine between 1,751 and 1,747 feet.

First opening
made on coal
in sec. 12.

Below this the stream falls at about the same rate for a short distance and then the grade is not so steep, as where it crosses the road between sections 10 and 11 the creek bed is at 1,706 feet.

On the stream which traverses the south-east corner of Section 12 no exposures were seen, but from the elevations, the four-foot seam might be expected near the centre of Section 2. The ground behind Mr. Proudfoot's house is at 1,758 feet.

Northward the next exposures of coal of this horizon are on section Sec. 25, 25, where a deep ravine cuts through the edge of the terrace at a point where it is at about its highest. At Mr. Powne's house on the edge of the ravine a well was bored for 127 feet and passed through coal or

* Several holes are noted by Dr. Selwyn just north of the Vaden mine and in one not far distant a seam of 7 feet was struck at 30 feet from the surface.

coaly matter at about 102 feet. The curb of the well is at 1,853 feet and this brings the horizon of the coal at about 1,751 feet. To test this, Mr. Sherman, of Deloraine, put down a pit in the bottom of the ravine at or near the point where it forks. The elevation of the spot selected is 1,760 feet and the coal was struck at 8 feet, equivalent to 1,752 feet. Little information could be obtained as to the thickness found, but it may probably be assumed to be the same seam as at this elevation at the Vaden mine. A bore-hole was also put down, but the depth is unknown. The bed of the ravine slopes rapidly to the west and at the centre of the Section, or in a distance of about a quarter of a mile from the forks, the fall is 15 feet—enough to bring the bed of the stream below the coal seam, and it is very likely that a tunnel at this point into the bank would strike whatever coal there is. The section in the well shows a depth of about 25 feet of sand and sandstone above the coal with clay and sand higher up. A well north of the stable and upon the north slope, was bored from an elevation of 1,825 feet down to 1,760 in the sandstone, where water was obtained but without reaching the coal seam.

Sec. 36. Following this terrace northward to Section 36, a well at Mr. Morningstar's in a slight ravine in front of the house, passed through a small seam of coal and ended at a depth of 17 feet in another. The elevation at the well curb is 1,774 feet and at the coal about 1,756, or slightly higher than those determined south of this. A well subsequently bored from the top of the bank showed the thickness of the seam to be only 22 inches. The same seam was also struck by Mr. Poole, who lives on the north-east quarter of the same Section, in a well near his house. These borings seem to indicate that the coal of this horizon thins out considerably in going north, but this may be only a local feature.

Sec. 26. A lower horizon for coal is probably indicated by the presence of springs on Section 26 at about the 1,700 feet mark, though the boring at the Vaden mine showed nothing there as far down as that level. Along the eastern edge of Section 26 there are three small ravines with springs in each. The one near Mr. C. Corbett's house is about 30 feet deep and at an elevation of 1,700 feet a shallow well was dug through soil in which loose pieces of coal were found. The fact that the coal seams nearly always produce water would incline one to think that either coal or a very permeable layer of sandstone was situated beneath the tough clay which is reported as being bored through in another well near that at the house. Two miles south of this on the north-west quarter of Section 14, Mr. Hughes reports loose coal in a well

Sec. 14.

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dug in a low spot east of the house. This is on nearly the same elevation as the Corbett spring.

No other reported occurrences of coal were heard of to the west of this, and the wells in the vicinity of Goodland all seem to reach the gray shale below, which is probably Cretaceous, and the intervening sandy clays and shales which form the material between the elevation of 1,650 feet in Goodland and the foot of the slope at the 1,700 feet contour probably represent the Fox Hill sandstones.

North-eastward, the horizon at which the coal seams are supposed to occur does not appear to have been prospected or rather the bore-holes for wells have not been put down deep enough, so that very little information could be gathered. One exposure on the roadside in a shallow cutting at the north west corner of Sec. 8, Tp. 2, R. 23, shows a thin seam of lignite at 1,734 feet elevation. This is probably the same seam as the lowest streak of coal in Mr. Morningstar's well at 1,740 and the $1\frac{1}{2}$ ft. seam in the flowing well at Vaden at 1,732.

A long ravine running from the mountain in Sec. 1, Tp. 2, R. 23, passing through Sections 11, 14 and 15, is cut down through about forty feet of the rocks but the exposures along the sides are concealed by surface deposits. A small exposure of sandstone can, however, be found on Section 15. The coal seams evidently should crop out on the sides of this ravine, as they have been found by boring in the centre of Section 11 at the bottom of the ravine near Mr. Duncan McArthur's house. Here three seams were found with thin clay partings and the two upper ones are thick enough to work. Subsequently a shaft was sunk from higher ground and for several years a small quantity of coal was taken out during the winter months.

The section obtained by Dr. Selwyn, as published in the Summary Report for 1892, is given below. * 'On the north-west quarter of this Section, the owner Mr. Duncan McArthur has sunk several shallow pits, and a shaft 23 feet deep in which he states three seams of lignite coal were found with intervening clay strata.

	Feet.	Inches.
First seam at seventeen feet...	2	6
Second seam at	2	6
Third seam at twenty-three feet, thickness not ascertained.		

All the workings were full of water at the date of my visit. From the specimens of the lignite shown me by Mr. McArthur, it appears to be of similar quality to that now being mined at Estevan, and would

* Summary Report, Geol. Surv. Can., 1892, p. 4A.

certainly be a valuable fuel for local use if mined and sold at a reasonable figure.⁷

Sec. 11.

It is now about three years since this mine was operated, and as Mr. McArthur was absent, additional information as to the nature of the workings was hard to obtain. From Mr. R. W. Weaver of Deloraine, who had worked in the mine, I learned that the clay partings were not of great thickness, generally about 18 inches, but that sometimes the upper one disappeared or was replaced by coal and then the seam reached a thickness of six feet. The lower seam was not worked.

Sec. 24.

Smith's 7 ft.
seam.

From my levellings the elevation of the ground at the pit is at about 1,825 feet. This would place the top of the upper seam at 1,808 feet and the bottom of the second seam at 1,802 feet. The seam slopes, according to Mr. Weaver, slightly to the north. This fall must be slight as at the next point where the seams have been bored into, at Mr. Smith's on the south-west part of Section 24 in the same township, the elevation of the top of the coal is at 1,783 feet. This is about a mile and a half north and half a mile east of McArthur's, and shows a fall in that distance of 25 feet. Mr. Smith in digging a well near his house struck the coal at 24 feet and dug into it three feet. He then stoned up the well but afterward was induced to try and ascertain the total thickness. His efforts in reaching the base in the narrowed diameter of the well enabled him to get down about four feet, so that he has hopes that the seam is seven feet in thickness.

Probable
outcrop.

These estimates may be over rather than under the actual amount and it would seem, that here the two seams that occasionally form a six feet seam in the McArthur mine are brought together again. If there is over that amount here the seam should be worked, as fuel in the district is getting scarce and there is a large local market. The ravine leading north from McArthur's should afford good points for the mining of this seam without the necessity of raising and pumping by steam or other power. The slope in the ravine north is quite steep and the fall from the mine to where the road between Sections 14 and 15 crosses it is 57 feet, and 45 feet below the ground at Smith's house or well. It would thus seem that the lignite should outcrop in the ravine on Section 14 and along the sides on Section 15. At Smith's the coal can be got at from the level by a long open-cut from the north, as the ground slopes to the north and a point at the centre of the farm in a ravine which heads in two branches on either side of the house is 25 feet below the top of the coal.

Urie's well.

On the eastern part of this Section Mr. Urie has dug a well 50 feet deep without reaching the coal but as the elevation at his house is

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about 1,830 feet his well at the bottom is very close to its probable position.* In the next township to the east very little was heard of any discoveries of coal, but there is one point of interest in connection with the possible future discovery of seams of workable thickness in the existence of a deep ravine crossing the western tier of sections, convenient points from which to work should be there found. From the levellings at Smith's and across the ravine on Section 19, Township 2, Range 22, it would seem that if the level of the seam continued to the east at nearly the same elevation, the outcrop would reach this ravine north of the centre of Section 19 and be found by drifting along the slopes as far up the valley as the road crossing at the south side of the same section. Mr. Renton who owns the section and lives on the south-west corner of Section 20, has bored a well at the top of the bank near his house and by this has proven that there is no coal down to within a few feet of the 1,800 feet elevation. He has also sunk a well in the bottom of the ravine from about 1,788 feet and finds there loose pieces of coal. The question of the coal existing between these two elevations has therefore not been tested. Renton's section.

Eastward, in the next township, little could be learned of any discoveries of coal, but the lines of equal elevation follow a direction about E.N.E., and the probability of finding any would be greatest in Sections 19 to 24, although on Section 25, belonging to Mr. Shepard, loose coal is reported in a well in the bed of a ravine on the northern part. Higher up the slope there are, unfortunately, but few bore-holes, and the only discovery reported is of a seam a few inches in thickness on Section 4, owned by Mr. G. Rickard. In the mountain on Section 24, Tp. 1, R. 22, at an elevation of about 2,200 feet, Mr. H. Russell found a small mass of loose fragments of poor lignite in a small well near his house. This may have come from the drift, as this part of the mountain is thickly covered by boulder clay and there seems little evidence that exposures of the underlying rocks would be found in a shallow well. Tp. 2, R. 22.

On the road south from Boissevain, sections of the underlying strata are seen on the road cuttings and in a series of quarries to the south of the town. On the road passing along the eastern boundary of the township and at a point south-east of the town, sandstone of a soft character is obtained on the north front of the steep incline, and also in a deep ravine crossing the road. On the road a mile west, running south from the western edge of the town, dark yellow sand is exposed at the top of the hill in the road cutting at an elevation of 1,729 feet. South of Boissevain.

* In Dr. Selwyn's note-book for 1884, it is learned that Mr. Urie, west of Deloraine (Old Deloraine), cut 3 feet of coal in a well. What section this is on can only be conjectured as it is possible it is the Smith location.

Sandstone
quarries.

A harder layer, and probably the same bed as that quarried in the hill a mile east, is exposed in the banks of a creek running through Sections 11 and 14 and stone for several fine buildings in Boissevain has been taken from a quarry on the south-west part of Section 11 or the adjoining part of Section 10. The upper part of the exposures along the creek are of dark yellow sand with a few reddish streaks from ironstone. This is also exposed in a ravine on the north part of Tp. 2, R. 19, and is mentioned by Dr. Selwyn in Report of Progress for 1879-80, p. 11A.

Below these sands at the quarry is a lighter coarse-grained sand in false beds and irregular layers not apparently hard enough for building purposes, but below this is a dark gray sandstone, the cracks and crevices in which are stained dark with iron rust. This stone is probably near the base of the series and may represent the Fox Hill sandstone at the base of the lignite Tertiary. This would consequently be the northern limit of the coal-bearing rocks of this area.

Shales north
of mountain.

In the lower ground on which the town is situated wells that have been bored reach the shale which underlies all the country to the east and north as far as the edge of the Peubina mountain. The well bored on Section 19, five miles west of Boissevain, did not reach the shale, though 75 feet of drift were penetrated. A boring on Section 34 north-west of the town went through 63 feet of clay, 4 feet of sand and 103 feet of shale, and the well bored in Section 23, just west of the town, gives a section of 64 feet of clay and hard-pan and 198 feet of shale. This shows that the shale is the underlying rock up to the foot of the hill south of the town. The sandstone probably skirts the edge of the hill westward, and occasional outliers occur even as far west as Waskada in thin sheets and are pierced by wells. South of the quarry traces of coal have been found at several different horizons.

Tp. 2, R. 20.

The lowest coal heard of is in a well on north-east quarter of Section 35, Tp. 2, R. 20. There were three inches of very poor lignite at a depth of 12 feet from the surface. Elevation above sea of this coal is 1,772 feet. The next is on the south-west quarter of Section 24, same township, where Robert Johnston found four feet of lignite in a shallow well dug in a depression draining north near the western boundary of the section. The well is dug through eight feet of sand and clay and then through a four-foot seam of the coal. As it was full of water at the time of my visit the character of the seam could not be examined. The surface of the ground at the well slopes gently to the north, and though the seam is not far from the surface it would have to be worked by a shaft and drained possibly by a long drain or open ditch running from near the north boundary of the section.

Johnston's
4 ft. seam.

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On the south-east quarter of Section 13, Mr. J. Dalrymple had a well bored in which the seam was reached at a depth of 25 feet, but the thickness did not seem to be as great as on the Johnston property. Samples of the coal which had been kept for over a year showed bright fractures and a good quality of lignite. The elevation of the seam is approximately 1,845 feet and at the former place between 1,836 and 1,832 feet. On Section 12, just to the south, Mr. Glover, who owns the east half, found coal in his well on the edge of a ravine which runs north-east across the section. At a depth of fifteen feet a two feet seam was passed and after boring through six feet of clay another seam was reached in which a supply of water was obtained. The thickness of this was not ascertained. As the ravine is twenty-eight feet below the well, curb these seams could be worked from the level very cheaply, even though there is not a great thickness of coal. The two-feet seam in Glover's well is at 1,898 feet and the top of the lower seam at 1,892. Glover's well.

A quarter of a mile up the ravine Mr. A. M. Ross also reached coal in a well at a depth of about forty feet. As the elevation of the ground is above that at Glover's, the same seams would probably be reached between forty and fifty feet below the surface. Other reported occurrences of finding coal in wells in this vicinity are on Sections 14 and 15, where Wm. Hall and Mr. Wilson both report reaching a seam at about 25 feet, probably the same one as the Johnston seam. Ross' well.

At Lake Max in the mountain at an elevation of about 2,200 feet, Mr. Cox, who lives on Section 31, Tp. 1, R. 20, dug a well for Mr. Kasper Killer on one of the islands, and at a depth of 27 feet found coal. This was not dug through but it tends to show that there is a possibility of there being several horizons above that outlined on the lower part of the slope of the mountain in which the lignite may yet be found in paying quantities. Lake Max.

Few reports of coal could be obtained from residents of the townships to the east. Many farms having changed hands within the last few years after the wells had been dug, the present owners have no knowledge of the strata passed through. On Section 27, Township 1, Range 18, a well is reported as having been bored through a coal seam, but the present owner could give no definite statement to that effect. On Section 15 in the same township shale of a light gray colour is exposed in the garden at Mr. Mitchell's house, and also in a shallow well in the bed of a small creek south of the house. There is no direct evidence of the presence of any coal, but it would seem to show that in places the surface covering is thin. On Section 12 an old resident Tp. 1, R. 18.

reported that coal had been found some years ago in a well, but the present occupier of the lot, Mr. Reedman, could not corroborate the statement. A new well at his house was dug through forty feet of sand and clay with no coal. Mr. E. C. Skinner on Section 18, Township 2, Range 17, found a small seam at 28 feet below the surface which he thought was about one foot in thickness. The elevation of this seam is approximately at 1,824 feet above the sea.

Bore-hole by
Dr. Selwyn.

The Turtle mountain bore-hole which was sunk by Dr. Selwyn in 1880, is referred to in the report for 1879-80, p. 10A, and by a misprint its location is wrongly stated. Its situation is on the south-east quarter of Section 5, Township 2, Range 19, and is at the mouth of a small ravine just at the edge of the woods. The location seems to have been unfortunate as apparently there was a previous depression filled in with boulder clay and sands and gravel. The bore was carried to a depth of 200 feet without any seams being found. As the elevation of the ground there is about 1,955 feet, it seems remarkable that no trace of the seams which are known to occur at 1,835 and 1,890 feet, a short distance to the west should have been noticed.

Many occurrences have no doubt been missed in this hurried examination and more complete information might have been obtained had we means to test by bore-holes both along the outcrop and up the slope of the mountain.* In this manner a section of the mountain could be made. As it was, much of the time was taken in making a contoured plan on which to base future work.

The result of the series of levellings shows that though the coal seams are approximately horizontal, still there is a general slope to the westward of slight amount as well as a local bending to the north along the north slope of the hill.

Formation
of coal.

The coal horizon does not appear to consist of a series of seams in continuous sheets but rather of deposits which are limited in extent though repeated over large areas and often superposed without the intervention of much sand or clay. A thick seam may thus be represented in an adjoining locality by a series of thin seams separated by sheets of sand or clay. The material from which the coal was derived seems in many instances to have been made up of a large percentage of woody matter, but a great part is probably composed of much smaller plant remains similar in character to much of that in our present swamps and peat bogs though of different species, such as would be

* Dr. Selwyn records a sample of coal from a well on Highman's location, Section 34, Township 1, Range 19.

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found in a warmer climate. The shales above the coal in the Souris coal-field (a continuation of these deposits) contain along with a variety of tree leaves, the remains and impressions of many grasses.

The clays and sands which are contemporaneous with the coal seams contain fresh-water shells, so that the ordinary land conditions prevailed only at intervals and the vegetation which sprang up became concealed by deposits which were drifted over them by the invasion of fresh or brackish water. Repeated changes of this nature enabled the accumulations of similar material to be so piled one above the other that with a lapse of time the vegetable matter became so consolidated that its composition approached that of the older coals.

A GEOLOGICAL RECONNAISSANCE ABOUT THE HEAD-WATERS OF THE ALBANY RIVER.

Dr. Alfred W. G. Wilson.

Your instructions of date May 24th, 1902, advised me that, in com-
pany with Mr. J. F. E. Johnston, C.E., of the Survey staff, I was to Instructions.
undertake a geological reconnaissance of a portion of the southern part of Keewatin district, lying to the east of the area explored by Mr. D. B. Dowling, B.Ap. Sc., in 1893. Mr. Johnston was delayed a few days at the office preparing plans for the season's work, but was able to meet me at Owen Sound on June 7th. We reached Port Arthur on June 9, where I purchased the bulk of our supplies and one large canoe. Leaving Port Arthur on June 10th we stopped off at Ignace to procure a canoe belonging to the department which had been left there by Mr. McInnes at the close of last season. We found that this canoe had been used by the man in whose care it was left and that it was not immediately available, being out at Sturgeon lake. I wired to Port Arthur for another canoe to be forwarded to Dinorwic, where we intended to leave the railway. We reached Dinorwic on June 11th, and were delayed there until the 14th, partly on account of the unsettled condition of the weather, and partly because we had to wait for the second canoe to reach us from Port Arthur.

At Dinorwic we procured the balance of our supplies and engaged Delays.
a crew of four men, three of whom had, the summer before, been over a considerable portion of the country we expected to explore. Leaving Dinorwic on the 14th of June we were delayed by unfavorable weather and did not reach Lac Seul Post until the 19th. Here we were again delayed some days, partly by unsettled weather and partly because at the time of our arrival the men were away with the York

boats and we could not at first find a guide who knew the Wenassaga route which my letter of instructions directed us to survey through to Cat river. Having engaged a guide, we left the post on the morning of June 23rd and reached the mouth of the Wenassaga river, a mile or two east of the outlet of Lac Seul, on the morning of June 29th.

Method of
survey.

We had previously arranged that Mr. Johnston was to take charge of the topographic work, and that I was to attend to the geology, assisting Mr. Johnston where necessary by local surveys off the main line. Mr. Johnston began a log and compass survey of the route from the narrows of Lac Seul, running about eighty-five miles of line, to Slate lake on the Wenassaga, reaching there on July 2nd. On this date the Ashton Kay patent log he was using was accidentally injured, and he decided to run the line by micrometer telescope and compass as far as Gull lake. Continuing from here, surveys were made of seven lakes, varying in size up to about six miles in length. In most cases the shore lines were very complex, with many deep narrow-mouthed bays running off from the main lake, an incidental feature of the lakes of the Laurentian upland almost anywhere.

Gull lake.

The height-of-land portage, half a mile in length, and longer than any of the 23 other portages between here and Lac Seul, was crossed on July 15th, and the survey of Big Portage lake, on the Cat river system, begun. The survey of this lake was finished on the 17th and on the 18th we crossed the short portage to the most western bay of Gull lake. Gull lake proved to be very large, with numerous deep bays, and our time until July 30th was employed in the survey of the portions of this lake which lay on the direct route, Mr. Johnston's survey being tied to Mr. Fawcett's line at the portage out of the south-eastern part of Gull lake—Smooth Rock lake of Mr. Fawcett's plan. As a considerable portion of our limited time had now been spent, we were compelled to leave several large bays of Gull lake, off the main route, unsurveyed. On July 30th we started for the Hudson's Bay Company's post on Cat lake, as from the account we had heard we judged that the balance of our time would be required for the survey of this lake. The post was reached on the evening of July 31st, and on August 1st the survey of the lake was commenced. The work was continually interrupted by bad weather, and the survey of the shore of the lake, and of the adjacent islands, occupied us until the 19th. As Mr. Johnston did not consider that the remainder of the time at our disposal was sufficient to complete the survey of the islands in the main portion of the lake, and as it was obviously too short to continue the line as far as the height of land towards Severn lake, I decided to return *via*

Cat lake.

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the Cat river route to the east end of Lac Seul, and to attempt to locate the southern boundary of the belt of so-called Huronian rocks which outcrop further east on Lake St. Joseph, or Osnaburgh lake. In descending the Cat river I made brief geological notes *en route*. We reached the mouth of a small creek entering Lac Seul from the northwest on August 26th. This creek flows through a rough country burned over about six years ago, and all its portages had to be cut out as we ascended. On August 28th we reached the limit of canoe navigation, the upper part of the stream being very shallow and blocked with timber, and started on our return trip, reaching Lac Seul next day. We returned directly to Dinorwic, arriving there on the evening of Sept. 2nd.

During the season we experienced much stormy weather with frequent thunderstorms, causing numerous interruptions of the instrumental work. The total of these delays in intervals of from one hour to a day and a half, caused a loss of about seventeen days in all. Towards the end of July and in the early part of August our work was materially retarded by some difficulties with our men, who were very much afraid of entering the country in the vicinity of Cat lake on account of current rumours respecting the dangerous character of the Indians of that region.

TOPOGRAPHY.

Topographically the region through which our exploration line passed is a portion of the great uplifted modified peneplain of the Archaean rocks of central Canada. Throughout this portion of southern Keewatin, the various water bodies lie in shallow basins in the peneplain surface. The maximum relief in the interior, except in the case of a few monadnocks, is rarely over fifty feet; near the southern boundary of the district, the relief is somewhat greater. In a few places, ridges or isolated more or less dome-shaped masses, rise above the general level of the peneplain. One of the most striking of these lies to the west of Cat lake and has an elevation above lake level of about ninety-five feet.

The lakes are shallow, marshy, very irregular in outline, and at times more or less bounded by areas of muskeg (marsh). The inter-stream areas are bare, rounded or undulating surfaces of rock, frequently clothed, especially in the hollows, with a thin drift cover of sandy soil and boulders, overgrown and concealed by a dense mat of moss (generally *Hypnum triquetrum*) and interlaced roots. As a rule the drainage is very imperfect. Occasionally there are small areas, underlain by a thicker cover of drift or by a glacial sand plain, where the drainage is better and the moss cover is absent.

GEOLOGY.

Rock
formation.

The rocks of the area may all be classed as Archæan. For the most part they are acid, igneous or metamorphic rocks, generally some variety of either granite or gneiss of some light shade of gray or pink. Associated with these, are several belts of dark-coloured, generally almost black, basic rocks, usually micaceous schists, less often hornblende or chloritic, which are similar to those which have elsewhere been tentatively classed as Huronian. In general features they closely resemble the rocks in the vicinity of the Lake of the Woods classed by Lawson as "Keewatin"*. The broadest belt of these rocks was crossed by our line about 38 miles (by water) above Lac Seul, and extends in the direction of the line for a distance of about 20 miles. The precise width of the belt cannot be determined until the survey is plotted. Slate lake, around which the best exposures are found, runs in a direction nearly parallel to the strike. The western extension of this belt is represented on Mr. Dowling's map of the 'Vicinity of Red Lake and part of Berens River,' and described by him in his report on that district.†

Three belts of
Huronian.

A second narrow belt is crossed at the height-of-land portage leading into Big Portage lake from the waters tributary to the Wenassaga. The belt is narrow, probably not over a quarter of a mile in width, and exposures are few, at least near the portage. A third narrow belt (hornblende schists) is cut across by the narrow channel connecting the two western parts of Gull lake. In the vicinity of Cat Lake these basic rocks are known to occur only in a few localities, as small inclusions within the granites. Near the belts of basic rocks, it was found that there were generally numerous inclusions of the schists in the associated acid rocks in the areas on both sides of the main belt. At Cat lake a number of these inclusions are found, and there are also in places many drift blocks of similar material, so that it is quite probable that another belt of these basic rocks lies to the north-east of the lake.

Descending the Cat river a narrow belt of the basic rocks outcrops a short distance above Cross lake. Several other similar bands of the same rocks occur between here and Lake St. Joseph, particularly in the vicinity of Black Stone lake. A wide belt of these rocks, already referred to by Dr. Bell in early reports of the Survey, occurs at the south-west end of Lake St. Joseph. This belt extends towards the west and it is not impossible that the broad belt exposed in the vicinity

* Annual Report Geol. Surv. Can., vol. I, (N.S.) 1885, part cc, page 10.

† Annual Report Geol. Surv. Can., vol. VII, (N.S.) 1894, part F.

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of Slate lake may represent its westward extension. The other narrower bands along the Wenassaga seem to have their counterparts along the Cat river. It seems improbable that they extend as continuous bands between the two localities.

ECONOMIC GEOLOGY.

In almost all cases these basic bands are found to contain small Pyrites, (more rarely large) veins of quartz. In some few cases there is a small amount of pyrite in the schists near the quartz veins. At the surface these veins and the associated schists present the usual rusty appearance due to the decomposition of the pyrite. In most cases the veins seen were small, and it is improbable that (with one or two exceptions) they carry anything of value. A prospecting party working in the district during the summer has located a number of prospects along the Cat river. Whether they have discovered anything of value is not at present known.

The granites are occasionally cut by pegmatite dykes. In one Molybdenite, locality near the head of Cross lake a rock, apparently of this character, carries a small amount of molybdenite in crystals varying up to about an inch and a half across. Whether the mineral occurs in sufficient quantity to be of economic importance has not yet been determined. The property is at present in the hands of Mr. C.W. Ross, of Dinorwic, to whom the writer is indebted for specimens of the mineral.

Near the inlet into Slate lake, about three-quarters of a mile from Magnetite, its north-east end, on the eastern shore, Mr. Johnston noted in the schists small stringers of a metallic mineral, probably magnetite, as the local variation of the compass was considerable. Magnetite in small amount is a constituent of many of the basic rocks. This was, however, the only locality where it was found sufficiently segregated to produce a noticeable local variation of the compass. No occurrence of hematite ores was noted.

TIMBER.

The timber throughout the areas where our explorations lay is Timber, small; in most parts of the district apparently too small for use even for pulpwood or ties. The general aspect of the forest and the age of the various kinds of trees indicate that forest fires have swept over the region at intervals. On the islands, or in localities otherwise protected, one frequently finds fairly large trees, so that there is no reason to think that the small size of the forest trees is to be attributed to the character of the climate.

GAME.

Game.

Large game is fairly plentiful in the southern parts of the district, but in the central portions and around Cat lake it seems to be scarce. Game birds, except water fowl, are not plentiful. The region around Cat lake is a breeding ground of the mallard duck. The common fur-bearing animals of our northern districts are found here, though no species is very abundant, and some, particularly the beaver, are scarce. So far as could be ascertained, no brook trout occur in any of the streams; whitefish and sturgeon are taken in some of the larger lakes; pike are found in all the waters.

I wish, in conclusion, to acknowledge our indebtedness to the officers of the Hudson's Bay Company in charge of the posts at Dinorwic, Lac Seul and Cat lake, for many courtesies, particularly for the assistance rendered in procuring suitable men, and in storing supplies and outfit.

REGION ON THE NORTH-WEST SIDE OF LAKE NIPIGON.

Mr. William McInnes, B.A.

Assistant.

I left Ottawa on the 3rd of June, accompanied by Mr. E. A. Small, of Montreal, who had been appointed as field assistant for the summer. Mr. Small remained in the field until August 21st, when he was allowed to return in order to take up his work at McGill University.

After buying canoes and provisions, Nipigon station was left on the 8th of June, and Lake Nipigon reached on the 12th.

Starting point
of survey.

According to instructions, the work of the summer was to be carried on in the country lying to the west and north of the upper part of Lake Nipigon, with the object of gathering the data, both topographical and geological, necessary for the completion of the forthcoming map of Lake Nipigon and the surrounding country, and of exploring the district lying to the east of that reached last year from Sturgeon lake.

Trap hills.

After being detained by heavy winds for two days, Nipigon House was reached on the 16th, and an examination of the shores made, up to the mouth of the Wabinoish river. A micrometer telescope survey was started from the mouth of the Kobka river (the south branch of the Wabinoish). The river, which was found to be at a very high

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stage, shows here and there cut banks of a white, silicious sand, which fills the bottom of the narrow valley between the high trap hills through which the river runs.

Jegemassin and Kobka lakes, successive expansions of the river, are surrounded by high hills of trap, rising three hundred feet above their level. From Kobka lake a portage leads over a high hill rising 200 feet above it to Obowanga, the principal lake on the river. Extending south-east and south-west, it has a length of thirteen miles, and varies in width from half a mile to a mile. Everywhere along the lake the prevailing trap hills occur, though on the north shore these are some miles back from the water, the intervening flat land being occupied by an area of sand and gravel at a level of about fifteen feet above the lake. The main river falls into this sheet of water at its north-east corner. After surveying Obowanga lake, a stream entering its extreme western end was followed almost directly westwards. Leaving Obowanga, the underlying felspathic schists of the Huronian are exposed, striking about east and standing almost vertical. The stream followed proved to be a series of long narrow lakes connected by rapids and falls, the levels rising rapidly until, at about thirty miles from Lake Nipigon, a height of 1,350 feet above sea-level is reached, with neighbouring hills rising 200 to 300 feet higher. The north-west edge of the Huronian belt is here reached, the general trend of the contact being about north-east. No travelled route extends up this stream, so that it was necessary to cut out portages from lake to lake, most of them over very rough ground.

North-west
limit of
Huronian
belt.

Returning to Obowanga lake, another route was followed from its south-west bay to Otter lake and thence westerly. Otter lake occupies a long narrow valley hardly wider than the lake itself, with high hills of Huronian schist rising on the north side 200 to 300 feet above its surface, and on the south side nearly 500 feet. The main inlet of Otter lake comes in from the south at the head of the lake, discharging through a gorge so narrow that, excepting at extreme high water, the stream makes its way underneath the piled up debris of angular blocks fallen from the cliffs on the sides. The stream occupies a narrow valley with a high cliff facing it on the west side, and still higher hills rising sharply on the east.

Leaving Otter lake, a portage two miles long climbs in a steep slope up the almost vertical side of the valley, reaching a height of over 300 feet above the lake and descending again 100 feet to a smaller lake from which a portage three-quarters of a mile long leads to one of the head-waters of Gull river. Huronian schists occur all along, preserving

Route west-
erly from
Otter lake.

a generally regular strike N. 70° E. and dipping nearly vertically. This branch of Gull river was followed westerly for about six miles, where its course changes somewhat sharply and it splits into two branches coming from the south.

Head waters
of Albany
river.

A series of lakes, flowing into this branch from the west, was followed and a divide crossed to lakes emptying northerly. Similar schists of the Huronian occur all along with the same general strike and dip and give place, at the head of this series of lakes, or 37 miles west of Lake Nipigon, to biotite granite-gneisses, which continued westward beyond Shishibak lake, the most westerly point reached. The country seen from this lake on every side, is comparatively flat, no hills rising more than fifty feet above the general level which reaches 1,600 feet, or thereabouts, above the sea. The forest growth is generally small, owing probably to the thin covering of soil: it is everywhere green and no general fire has burned over this area for a great number of years.

Obowanga
lake to Gull
river.

Returning to Obowanga lake, a route was surveyed from its southwest bay across to Gull river and thence down the river to Lake Nipigon. The southern edge of the Huronian belt above referred to lies about a mile to the south of Obowanga, where it is in contact with the granite-gneisses that continue to the south and is overlain by the traps of the Nipigon series on the east. The width of the belt of Huronian thus defined is about eight miles, measured where it disappears under the trap capping.

Gull river.

From the point where the Gull river was reached, to its mouth, it is a deep, smooth-flowing stream, broken in this distance (about 18 miles) by only three short rapids. It has a fairly uniform and strong current and has cut its channel to a depth of from ten to thirty feet in the drift deposits of the valley.

North branch
of Wabino-sh.

For the purpose of further exploring the area under consideration, the north branch of the Wabino-sh river was then followed nearly to the height of land, and a series of lakes and streams lying further to the west was surveyed by micrometer telescope. These lakes and streams included a number that flow northerly by way of Smooth rock and Island lakes and the Okoki river into the Albany river. Among them Shawanabis has a length, east and west, of about sixteen miles with a long arm extending southerly at its western end.

Character of
rock expo-
sures.

The traps of the Nipigon series are the only rocks seen all the way up the north branch, with the exception of two isolated areas of gneiss occurring at Waweig and Washebimega lakes, where they are exposed by

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the denudation of the overlying beds. The edge of the main area of the traps, where they overlie the gneisses, is reached at about three miles west of the north branch, beyond which only granite-gneisses occur.

Leaving Shawanabis, a route was taken leading southerly through Waterfalls, smaller lakes to the Kopka river, flowing into the east end of Obo-wanga lake. This is a river of fair size, the largest of the Wabinosh streams, that has not yet appeared upon published maps. Along its course occur a series of lakes, the principal of which are Kenakskanias five miles long, Wigwasaus six miles long, and Bukemiga eight miles long. Between Kenakskanias and Wigwasaus, in a distance of a little over a mile, the river descends 250 feet in a series of rapids and cascades.

At the foot of this drop the edge of the Nipigon series is seen, flat-lying beds of white and red siliceous sandstone protruding from beneath a thick covering of trap. From this point eastwards to Lake Nipigon the traps are continuous excepting where, in some of the valleys, denudation has exposed the underlying rocks in limited areas. These are elsewhere more particularly noted.

The White Sand river, which empties into Lake Nipigon on its western side two miles and a half south of Mount St. John, was then ascended and the lakes along its course examined. The river and its lakes lie in an extensive, rolling, sand plain, underlaid by granite-gneisses.

Through this overlying sand the river has cut to depths reaching in places 100 feet, and cut banks of sand of that height occur along its lower stretches.

The white siliceous sand covers an area many miles in extent. The surface of the plain is gently rolling, its generally level character modified only by occasional low ridges and by the valleys cut in it by streams. The tops of the ridges are generally quite bare of vegetation, the loose sand, readily drifted by the wind, affording no hold even for the mosses that cover it in more protected places. The side of the ridges and the valleys support a limited growth of coniferous trees of small size.

The Pikitigushi river, flowing into Wendigo bay, was then examined. From the mouth up to Round lake its course is winding in the extreme and few exposures of the underlying rock are seen, the banks being made up of sand. Cliffs of trap are, however, seen here and there at

Height of
land.

Outliers of
trap.

no great distance from the river. At the north end of Round lake a belt of Huronian schists and diorites form the hills back from the shore. Continuing up the river, its valley is found to have been cut down, through the overlying traps into the Huronian schists and granite-gneisses, the inclosing hills still showing cliffs of the overlying trap. The same conditions extend across the height of land and down northwards to the Okoki river, where the edge of the trap overflow is reached and where the granite-gneisses are seen, immediately underlying the traps, the latter cutting the gneisses in dykes, arms and irregular masses. To the northward of the edge of the main area smaller isolated areas of trap are here and there seen, generally in the form of conical hills, showing that the trap once extended for some distance to the north of its present limit.

Excluding recent drift deposits, there are represented in the area under review, only the granite-gneisses and crystalline schists and associated rocks of the Laurentian and Huronian and the unconformably overlying sedimentary series of sandstones, limestones, etc., known as the Keweenawan or Nipigon series. All of these are cut and overlain by a later basic intrusive that varies from a fine diorite to a coarse gabbro.

Topography.

This sheet of trap gives to the whole basin occupied by it a highly indented topography, characterized by high, comparatively flat table lands, intersected by deep narrow valleys. The sandstones and limestones are seen at but few places, at the base of cliffs of trap that overlie them and at the edge of the basin where they protrude from underneath the trap. Outliers are seen in a few places lying on the old rocks at some distance from the confines of the main area, but for the most part they have been entirely denuded where unprotected by the capping of more resistant rocks.

Dykes.

Where the underlying gneisses are exposed near the edges of the trap-covered area both on the west and north they are cut by numerous dykes of the intrusive rock, long apophyses extending off in places far into the gneisses forming ridges that by their black colour are in sharp contrast with the invaded gneisses. This dissimilarity has induced some prospectors to locate claims presumably for iron, or perhaps for general results, along these arms.

Economic
minerals.

No minerals of economic importance have been found in the district, though the belts of Huronian schists to the north and west of the lake make the occurrence of gold and iron not improbable. Iron ore, in the form of float, has been found at several points, but its source up to the present is not known. A deposit of iron pyrites of considerable

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extent occurs on the Pikitigushi river. Some of the siliceous sand-stones, which vary in tint from white to pinkish red, are of very even grain and would make good building stones were a demand for these ever to arise.*

Lands suitable for agriculture are confined mainly to the immediate shores of Lake Nipigon and to the valleys of the larger rivers and lakes. At Nipigon House the ordinary varieties of garden vegetables succeed very well; clover and various grasses grow luxuriantly, and oats sown late grew very long and strong, but were hardly ripe before the early frosts. Agricultural land.

Moose were found to be numerous in the district during the summer; Mammals. caribou fairly plentiful, and Virginia deer rare. One wolf was seen, and the tracks of others, running singly were observed. Bears, beaver, otter, marten and other fur-bearing animals still occur in good numbers, the unburnt condition of the forest favouring the preservation of the smaller fur-bearing animals.

Many of the streams entering Lake Nipigon abound in speckled trout (*salmo fontinalis*) of large size. In the White-sand river they were particularly plentiful, those caught varying in weight from one pound to three pounds. On the main lake one was taken that scaled six and a half pounds, and the diary at Nipigon House, the Hudson's Bay Company's post on the lake, records the netting of a twelve-pounder. That this was really *salmo fontinalis* there can be no room for doubt as the lake trout and brook trout are well known and clearly distinguished from each other by both the company's officers and the Indians. Whitefish and lake trout are also plentiful in the main lake, and lake trout, pike and doré in most of the smaller lakes. Fishes.

I left Nipigon House on the 7th of October and reached Ottawa on the 16th of the same month.

REGION LYING NORTH-EAST OF LAKE NIPIGON.

Dr. William Arthur Parks.

I have the honour to submit herein a summary report on the geology, physiography, economic resources, etc., of the region lying north-east of Lake Nipigon in the province of Ontario and constituting the eastern half of map-sheet No. 17 of the northern Ontario series. This sheet comprises an area measuring 72 by 48 miles, of which a considerable part is covered by the waters of Lake Nipigon. The area which I was Area examined.

* Dr. Bell with several assistants surveyed Lake Nipigon in 1869 and his report of that year describes the geology of its shores.

instructed to explore contains about 1,500 square miles of land surface, roughly defined as follows :—

The territory lying north of a line drawn due east from a point on Lake Nipigon, two miles south of Mungo Park point, a distance of about 25 miles west of a line drawn due north 48 miles from the eastern termination of the above east and west line, and south of a line drawn westward from the northern termination of this meridian, a distance of about 45 miles to the Jackfish river.

Previous
work done.

The shore line of Lake Nipigon bordering this region to the westward was examined by Mr. Peter McKellar acting under the instructions of Dr. Robert Bell, in 1869. At a later date, 1892 and 1898, Messrs. Dowling and McInnes made some further and possibly more minute surveys of parts of the shore line and some of the islands. The country inland was, however, practically unexplored, with the exception of the instrumental survey of the Obabika river made by Dr. Bell in 1871, when en route to the Albany river.

Instructions.

Early in June, I received instructions from Dr. Robert Bell, Acting-Director of the Geological Survey of Canada to proceed to this field and to examine as fully as time would permit the various features commonly dealt with in a geological report, as well as to extend our knowledge of the local geography by making track surveys of all water-courses in any way accessible. Special attention was to be given to the economic resources of the region and the condition of the timber throughout the district.

Route
followed.

Pursuant to these instructions I left Toronto on June 10th, proceeding by rail and steamboat to Port Arthur where a day was spent purchasing supplies, etc. On June 14th, I proceeded to Nipigon where I met my assistant, Mr. Paul Smith, of Windsor, Ont., and where I secured the services of two canoemen for the summer, as well as an additional man and canoe to assist in transporting the supplies up the river. On the evening of June 18th we camped at the north end of Flat Rock Portage on Lake Nipigon and were forced by a strong north-west wind to remain there the following day, but by paddling all night we were enabled to reach Poplar Lodge on the morning of June 20th. This point we made our headquarters during the summer, and I was fortunate in exchanging the large cedar canoe with which I had ascended the river for two smaller ones, more suitable for inland work.

Itinerary.

Having paid off one man, we proceeded directly to the Red Paint river, the exploration of which stream and its tributaries occupied us until July 16th, when we regained Lake Nipigon. Finding it neces-

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sary to go to Poplar Lodge for supplies I directed Mr. Smith with one man to proceed to the mouth of the Obabika river and await us there, while with the other man I went to Poplar Lodge and thence to the Obabika. Reaching there, I was surprised to find that Mr. Smith and man had not arrived. It appears that they had become lost on the lake and had wandered around for five days before we finally encountered them off Mungo Park Point. Arriving at Poplar Lodge I directed Mr. Smith to remain there until the kindness of the Algoma Commercial Company should afford an opportunity for his transportation down the river. From this time on, the work was continued with two men and one canoe. During the search for the missing men, I succeeded in working out the geology of the shore line between the Red Paint and Obabika rivers. On July 26th we started the ascent of the latter river and carried a traverse to the border of the sheet. Several overland expeditions were made and two connections established with previous excursions from the Red Paint. A winter road north of the river gave access to the lake at the head waters of the Kabasashkandagogama river, thus extending the section north and south a considerable distance. The more westerly section was brought to the northern boundary of the sheet by the northward tendency of the river from Summit lake on the Obabika. The work on this river was finished by August 10th. Thinking it advisable to examine the eastern extension of the South Obabika trap area, a trip overland was made from the south-east corner of Obabika bay, and to determine the elevation of the trappean hills forming the south peninsula of Obabika, an excursion was made across this strip of land.

On August 14th we began the exploration of the country accessible by the Jackpine river which enters Obabika bay from the north. This stream was ascended as far as the border of the sheet and expeditions were made eastward from it. The Jackpine forms part of a canoe route to the Albany and connects with a route via the Obabika. On our return from this trip on August 18th a few days were spent in attempts to ascend the small streams entering Obabika bay from the eastward, but owing to their small size and the burnt character of the country but little return was obtained for the time and energy expended. Finding that the time could be more advantageously spent in the southern part of the sheet, we returned to East bay and ascended to the large lake crossing Beatty's line known as 'Little Long' lake, 'North Wind' lake, &c. From this lake expeditions were run north to the Red Paint river and eastward to the large lake forming the source of the south branch of the Red Paint. Though we failed to reach the big lake the expedition proved of service in fixing the position of the lake called Crooked Green on Mr. Dowling's plan. On August 29th I walked over-

Sturgeon
river.

land from the southern point of "Little Long" lake to the Sturgeon river in order to mark the rock contacts and to examine the timber of this region. The Sturgeon river was then ascended to the mouth of a large brook entering from the north about a mile west of the big bend. A traverse was carried up this river in the hope of making a connection with the aforementioned large lake on the Red Paint. We were successful in this as well as in locating some important contacts of rocks I had hoped to find. Poplar Lodge was reached on the return trip on September 7th. A heavy gale prevented our moving until Tuesday the 9th, but having recourse to the expedient of night travelling we arrived at Camp Victoria the next night and reached Nipigon station on the afternoon of September 11th. I paid off the men there and went to Port Arthur the same evening where the final business connected with the expedition was settled. I reached Toronto on September 14th, having been absent on the survey 94 days.

Duration of
trip.Nature of
work done.

The lines of survey above indicated were all conducted on "track" methods, connections to known points being made where possible, which frequently entailed arduous overland expeditions. Owing to the heavy nature of the travelling but small rock specimens were brought, about 150 of which are now awaiting examination. A daily record was kept of the pressure of the atmosphere and of the temperature of both air and water. The weather during the summer was very wet, thunderstorms and heavy rain being of frequent occurrence. In ten years' experience of northern Ontario I have no hesitation in pronouncing this the wettest season I have spent in the bush. The continual rains had the effect of keeping the poisonous flies in life long past their usual period of activity, both black flies and mosquitoes being in evidence up to the last day we were in camp. The highest temperatures recorded were 78° on July 1st and 79° on August 3rd, and the lowest day temperature 42° at 11 a.m., June 26th. Much lower night temperatures prevailed, ice being formed on several nights in August and September.

Temperatures.

PHYSIOGRAPHY.

Character of
country
examined.

The region under discussion, omitting certain trappean areas along the shore, consists of a table land not exceeding 400 feet in height, falling with some abruptness into Lake Nipigon. The height of land between the Nipigon waters and those flowing north and east may be said to lie just within the eastern border of the sheet and to be represented by an extensive level swampy tract extending from the vicinity of the 'dam' on the Sturgeon river northward to the boundary of the sheet. This wet area supplies a large brook entering the Sturgeon at

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the point above referred to. It sinks into a depression occupied by a large lake forming the head-waters of the south branch of the Red Paint river, supplies the drainage at the source of the north branch of this river and is responsible for Summit lake on the Obabika river, the head-water of both that river and a stream flowing north to the Albany river. This level tract is fringed on the west by a more rocky area and, at some points, considerably higher land through which the various rivers break on their way to Lake Nipigon. Evidences of considerable dissection are observable between this fringe of hills and the lake, giving a rough aspect to the country in places and producing a relief of about 400 feet. The general lines of dissection have followed the synclinals of the rock, the axes of which extend in a direction north of east and south of west. Erosion of these lines is facilitated in the Huronian areas by the correspondence of the prevailing strike with this general direction. The region is therefore a dissected tableland with a somewhat abrupt fall to Lake Nipigon and a gradual ascent to the eastward, followed by a minor descent occupied by a wet area constituting the source of a number of rivers. This general structure is, however, modified along the shore by the deposition on the flanks of the plateau of a coarse sandstone, overlaid by a trappean belt of about 300 feet in thickness. This basic rock forms a ridge, interrupted in places, extending along the shore line from the north to the south of the sheet. At its northern end this area is more distinctly ridge-like, while its southern extension attains a much less pronounced elevation and stretches farther inland. This structure is shown in the character of the shore line, for the northern ridge has obstructed the egress of the waters from the east, turning them southward and causing them to hollow out a shallow bay between the edge of the plateau and the range of trappean hills. At a later age an opening was eroded through the ridge so that the waters entering this bay, Obabika (Steep Rock gap) no longer were forced southward but escaped into Lake Nipigon by the means thus afforded. At the southern border of the sheet, the previously described contour is not materially affected by this trappean rock as its elevation is inconsiderable, but on proceeding northward, it becomes more pronounced, forming a promontory of 200 feet elevation at Livingstone point. This point is now an isolated mass as the forces of erosion have worn away the connecting rock both to the north and to the south forming deep bays, called by Dr. Bell, Humboldt and East bay respectively.

Red Paint river.

Nature of surface erosion.

Basic rock.

Trap masses.

The Sturgeon river, entering Lake Nipigon just south of our sheet, is the main line of drainage from the east; immediately north of it a rocky hill of 200 to 300 feet rises abruptly to the level of the plateau.

Lines of drainage.

Red Paint
river.Height of
land.

From this region the waters drain south by tumultuous streams into the Sturgeon. On ascending this river the banks are seen to have a lower elevation, and finally, at a point about 20 miles up, we enter the previously described low area, the southern part of which is drained into the Sturgeon by a stream from the north and west. Towards the north-east the marshy land extends to a large lake stretching for about 12 miles in the same direction and forming the source of the south branch of the Red Paint river. This stream falls over a granitic barrier and passes through the aforementioned ridge in a denuded valley, after running a few miles through the level country. A succession of shallow rapids continues to a lake a few miles long, below which the river is broken by some short rapids to the junction of the north branch. Below the junction one long rapid with a considerable fall intervenes before the stream passes into quiet water which extends for five miles to Lake Nipigon. The north branch is a smaller stream uniting with the former about seven miles up; its course is somewhat south of west, and a slightly different country is shown in the more numerous lake expansions on its course which approximates to the Huronian-Laurentian contact. This branch also traverses the low-lying tract, but its head-waters are in the more elevated land farther to the east. About one-third of the way from its mouth, the Red Paint river receives a tributary on the north which drains a considerable depression stretching for eight to ten miles in that direction. This depression is occupied by a number of long narrow lakes with a general north-east and south-west disposition. Continuing northward from the source of the Red Paint, the low land extends to a lake forming the source of the Obabika. This lake is three miles long, and from it a stream, still in the low land, leads to a lake about seven miles east and west which discharges by a sluggish stream into a muddy lake stretching three miles north. This lake occupies the Lake Superior-James Bay divide and sends a stream in both directions. The former, the Obabika, continues in the swampy land to Cross lake, where the higher land is met and the waters begin to fall over the ridge towards Lake Nipigon. They continue in a south-westerly direction through a Laurentian region, the only considerable tributary entering from the south and arising in the same depression of which the southern drainage falls away to the Red Paint.

North of the Obabika several small streams, not navigable, enter Obabika bay in a south-westerly direction. The most southerly is the Kabasashkandagogama, draining a lake of the same name which is accessible, not by the river, but by a small stream entering the Obabika from the north.

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At the north end of Obabika bay a stream known as the Jackpine Sand plains, comes in from the north, its lowest seven miles traversing a sand plain with jack-pine, above which point the country becomes more rocky and passes beyond the borders of our sheet.

GEOLOGY.

Three different formations can be recognized in the region—the Laurentian, the Huronian and the Animike. The Laurentian is represented by gneisses and granites varying from types with the most pronounced lamination to those of massive granitic structure. On the whole the rocks commonly classed as Laurentian, as far as this region is concerned, consist mostly of hornblende granite becoming gneissoid in places. An area of rock of this kind enters the northern boundary of the sheet at a point seven or eight miles from the north-east corner. It extends in a south-west direction to an apex a short distance west of Cross lake, where it again sweeps eastward and, after a considerable curve in this direction, reaches another westerly apex in the depression north of the Red Paint river. The line of contact then makes another easterly curve and turning west cuts off part of the Red Paint, finally reaching the shore of Lake Nipigon at a point just north of the mouth of this river. The area north and west of this broken line is occupied by Laurentian granites and gneisses, while that south and east is a region of Huronian schists. A second granitic area surrounds the large lake at the source of the south branch of the Red Paint, and seems to fringe the lake as a belt not over three miles wide. A third region of Laurentian rock lies inland about two miles from East bay. Like that just described, its centre is occupied by a large lake of eight miles extent, lying in a north-easterly direction which the rock surrounds as a narrow fringe. This is essentially a granitic type. Rocks of a more gneissoid appearance crop out along the shore of East bay, and in a south-east angle of Humboldt bay. I am inclined to regard these as a southerly extension of the large area of similar rocks already described.

Geological formations.

Hornblende granite.

Three Laurentian areas.

Except along the lake and in a limited portion of the south-west corner of the sheet, the remaining area is occupied by Huronian rocks, generally tilted at high angles with a strike averaging a little north of east. The schists are usually of an acid type, apparently mostly of quartz-porphry origin, mixed with volcanic clastics. Basic schistose bands occur with much less frequency, as well as limited belts of diorite and diabase.

Huronian rocks.

Resting on the flanks of the northern Laurentian area, particularly south-east of Obabika bay, as well as in the north-east and south-

Animike sandstone.

east angles of Humboldt bay, are small areas of white to pink coarse-grained sandstone, referable to the Animike series. Smaller outcrops of this rock also occur at a few points along the western shore of the south peninsula of Obabika. In every case these deposits are covered by a dark basic rock of diabase structure rising to an average elevation of 300 feet. This Animike trap forms the whole of the north peninsula of Obabika, and, excepting a narrow fringe where the underlying gneiss is exposed, the whole of the south peninsula of the same name. The third area, the one with which the sandstone is particularly associated, lies east of the isthmus of Obabika and extends about five miles inland. Livingstone point, south of Humboldt bay, is a narrow peninsula composed of trap at its eastern extremity. This rock overlies a bed of sandstone at the western end of the point and extends a mile or two inland as a narrow belt overlying the Huronian. The final trappean area forms a line of contact from the south-east angle of East bay in a south-easterly direction for about eight miles, when it turns south and crosses the Sturgeon river at the top of the long rapids. The southern boundary of this area begins in a cove north of Poplar point, and stretches to the foot of the long rapids. It is this belt of trap that is responsible for the heavy rapids at this point.

SOIL AND TIMBER.

The height of land region at the eastern border of the sheet, though level and swampy, is mostly of a sandy nature as revealed in the river cuttings in the district. The rocky land farther west is covered, where any soil is developed, by shallow beds of sand, while the slope to Obabika bay and Lake Nipigon presents much more clay. Therefore, the best agricultural land in the region is to be found in a belt of about five miles width along the shore, particularly along Obabika bay and in the region immediately east of Humboldt bay. North of Obabika bay a little clay is found, but extensive sand plains cover it as we proceed northward.

The timber in the height of land region is small spruce and tamarack with Banksian pine on the sand plains and higher land. The central rocky region is better timbered, particularly along the rivers, but extensive fires have wrought havoc with the once abundant wood in these highlands. Both for agriculture, and for timber, the best is to be found on the clay land bordering the lake. Along the north shore of Obabika bay fires have practically destroyed the timber. On the lower reaches of the Obabika, however, and in the depression connecting that river with the valley of the Red Paint good stretches of spruce, balsam, poplar and birch still exist. Also north of the Obabika towards the

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Kabasashkandagogama and along East bay good timber is to be seen. The marketable spruce, which is really magnificent in this last region, has been unfortunately cut off a few miles east of 'Little Long' lake by an extensive fire from the south-west. All along the Sturgeon the timber is small, of about 20 years growth, while in the south-east corner of the sheet still younger forest is found. An attempt will be made in the final report to map the different areas of forest growth so as to bring out the disastrous effects of forest fires. For instance, one fire about five years ago started somewhere north of the mouth of the Sturgeon and swept across the country in a north-easterly direction, devastating the upper valleys of both branches of the Red Paint and stretching beyond into the basin of the Obabika.

ECONOMIC GEOLOGY.

Iron.—In the region lying immediately south of this sheet are three or four bands of Huronian rock sufficiently ferruginous to be known as the iron range. These deposits have already been described and need no further comment here. Both the Algoma Commercial Co. and the Flaherty syndicate, which have been engaged in extensive explorations on these ranges, have recently abandoned the region. This cessation of operations does not prove the worthlessness of the deposits, but merely that the expiration of options and heavy financial engagements elsewhere diverted the tide of prospecting from this region. Iron deposits similar to the above have been reported on the Red Paint river, but my observations, as well as the more detailed work of the above mentioned companies, failed to reveal any jasper bands, the infallible index of the iron range. One Andrew Green staked claims on Red Paint lake and at different points in the vicinity; the iron, however, is merely limonite and ochreous hematite in small masses, resulting from the decomposition of pyrite which occurs in certain sugary quartz seams running parallel to the inclosing schists. Iron ores.

Gold.—The Huronian rocks as usual carry small stringers of quartz, some of which may prove auriferous. On the south branch of the Red Paint, on Cross lake and on the upper portages of the Sturgeon good indications are seen, as well as on the streams over the height of land towards the Albany river. Specimens from the Obabika yielded traces of gold to the officers of the Crown Lands Department of Ontario. No indications of other metallic substances were seen. Of the non-metallic products certain of the fissile schists, particularly on the Sturgeon, would be useful for whetstones. Much of the clay along the shore line would be suitable for the manufacture of bricks and possibly would be of use for pottery. Gold.

Acknowledgments.

In closing, I wish to express to Mr. Eley of the Algoma Commercial Co., to Mr. Patterson of the Hudson's Bay Co., and to the officers of this company at Nipigon my sincere thanks for many acts of kindness during the summer.

RECONNAISSANCE SURVEYS OF FOUR RIVERS SOUTH-WEST OF
JAMES BAY.

Mr. W. J. Wilson.

Instructions.

Your instructions directed me to explore and survey the country lying between the Attawapiskat and Albany rivers, and also the country between the Albany and Moose rivers on the west coast of James Bay. In the first place you pointed out that the Kapiskau river would afford an easy means of access to the former region, and that there was reported to be a canoe route from Moose Factory to Fort Albany which followed branches of the Moose and Albany rivers flowing through the centre of the latter area; also to make a micrometer survey of the Abitibi river from the upper crossing of Niven's line to Moose Factory and to run a micrometer line from the latter point to the crossing of Niven's line on the Moose river.

Itinerary.

I left Ottawa on the 24th of May, accompanied by Mr. Owen O'Sullivan of this office as assistant, and proceeded by the ordinary canoe route from Lake Temiskaming to Moose Factory. We engaged two Indians at North Temiskaming and one at Abitibi Post who remained with us all summer, and besides these three we employed guides for short periods, who knew the different rivers we had to explore.

Kapiskau river.

We reached Moose Factory, June 20, having been delayed very much by stormy weather. We went from Moose Factory to Fort Albany in our canoes along the coast, and after securing a guide and supplies for six weeks we continued in a boat to the mouth of the Kapiskau river, which we reached July 2. We made a micrometer survey of this river for 200 miles up. At this point the numerous short bends in the river made progress so slow that it was deemed advisable to stop micrometer work and separate into two parties. This we did July 21. I followed the main stream making a track survey for about eighty miles, and I also explored some of the larger branches as far as I could ascend them with a canoe. Mr. O'Sullivan returned to the forks forty-four miles up from the mouth and made a track survey of the south branch called Atikameg (Whitefish) river by the Indians. He continued up this river 135 miles.

Atikameg river.

* Dr. Bell's report for 1869, describes the geology of both sides of Lake Nipigon and that for 1871, the geology of the Obabika river and the route thence north to the Albany.

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Having completed the examination of the two principal branches of the Kapiskau, we returned to the mouth of the Otadaonanis river, a large tributary which joins the main stream four miles from James' bay. Here Mr. O'Sullivan remained to make astronomical observations and to extend the micrometer survey out to the bay, while I made a track survey of the branch referred to above. We then returned south, Mr. O'Sullivan making a track survey of the coast between the mouth of the Kapiskau and Fort Albany. At the latter place we again separated to examine the country between the Albany and the Moose rivers. Mr. O'Sullivan went up the Albany to the upper end of Big island where a large river, called by the Indians the Kwataboahegan, enters from the south. He explored this river to its source. It forms part of a canoe-route between Moose Factory and Fort Albany used by the Indians only at high water, but no one seemed to know whether it would be possible to go through at this season, (August 11). The branch which forms the southern part of the route is known by the same name and enters the Moose river about fifteen miles south of Moose Factory, measured along the common canoe-route. The Albany branch is also known by another name which means Stooping, river, and to prevent confusion I have used this name on the accompanying map. Returning from Fort Albany to Moose Factory, I made a track-survey of part of the coast. On the 16th August, I reached the mouth of the Kwataboahegan river, on the Moose side, and began a track-survey of it, which I continued for ninety miles up. Having met Mr. O'Sullivan, who was successful in getting through, we completed the examination of this river and returned to Moose Factory, where we repaired our canoes and got supplies for the trip home. Leaving this post early in September, we made a micrometer survey of the Moose river up to the intersection of Niven's line, (1898) a distance of thirty-one and a half miles. We then returned to the Abitibi river and continued the survey up that stream to the intersection of Niven's line, at the 179th mile post, connecting with my survey of last summer. This completes the instrumental survey from Moose Factory to Lake Temiskaming by way of the Abitibi river and lake, and the canoe-route to Quinze lake. We finished the survey September 24, and came directly to Ottawa which we reached October 8.

THE KAPISKAU RIVER.

The Kapiskau is about a quarter of a mile wide for some distance from the mouth and has a width of from seven to ten chains to the forks. At forty miles up, a section was made which showed that the volume of water at this point was 566,000 cubic feet per minute (July 4). The width is seven chains with an additional three chains

for ordinary high water, and the greatest depth is eight feet. The current is swift and strong with frequent rapids which become more numerous as the river is ascended up to 212 miles. Then for a distance of twenty miles there are only a few rapids and moderate current, followed by thirty miles of swift water and rapids. Above this there is almost still water to the Kapiskau lakes and for some distance beyond. The fall in a few rapids amounts to three or four feet, but for the most part it does not exceed one foot, and many of them are mere ripples which I presume disappear in high water. In the whole distance travelled on this river, we did not require to make a single portage.

Character of
river valley.

The river has no distinct valley, but has cut its way into the thick clay covering that overlies the solid rock or into the soft rock itself. The banks are generally low, rising from five to twenty feet, and usually the land along the river for four or five chains back is higher than that farther away. The sediment deposited by the river when it is swollen by the spring freshets has accumulated year after year and has slowly built up a ridge close to the stream. It is also possible that the ice may have assisted in piling up the material along the banks in the same way that the shooting dykes are formed along the rivers in eastern New Brunswick and Prince Edward Island. This narrow ridge is well wooded where not burned, with large spruce, poplar, and at some distance from the coast, canoe-birch, fir, balm of Gilead and an occasional tamarack and cedar. The tamarack here has escaped the ravages of the larva of the imported larch sawfly that has done so much damage to it farther south, so that where it does occur it is green and healthy. Back from the river five, or six chains, the trees are much smaller and in many places nothing is seen but muskeg thinly covered with stunted spruce and tamarack two to eight inches in diameter, and an abundance of laurel (*Kalmia angustifolia*) and Labrador tea (*Ledum latifolium*).

Forest
growth.

Clay, sands
and shells.

For the first 125 miles the banks are composed of bouldery clayey and stratified clay and sand containing marine shells. At this distance the first rock exposures appear. The rock is a very soft reddish-brown argillaceous limestone mottled with greenish-gray spots and some layers are wholly of the latter colour. In places layers of the two colonies alternate. The beds as far as observed are horizontal. Near the surface where the rock is exposed to the weather it is broken up into small pieces, and when wet very readily changes into mud, but in digging down much larger and firmer masses are found. The rock where first seen and for several miles up the river, is so soft that the river banks are worn down just the same as clay banks, and no cliffs are seen. This continues up for more than fifty miles from the

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first exposure, when a considerable change takes place. At the 183rd mile of the micrometer survey a cliff nearly thirty feet high occurs, a section of which is as follows in descending order:—

	Feet.	
Grayish limestone in angular blocks, firm	3 0	Section of limestones.
" " " much broken, soft.....	1 6	
" " " slightly mottled with red ..	1 3	
" " " very soft	0 6	
" " " mottled with red, fairly firm ..	1 5	
" " " very soft	0 7	
" " " mottled with red	1 3	
Grayish and reddish limestone very finely broken	0 4	
Reddish limestone mottled with gray.....	1 8	
Grayish limestone, very soft.	0 2	
Reddish limestone, crumbling.....	1 2	
Grayish limestone, firm.....	1 0	
Mottled reddish and grayish limestone, very soft.....	1 3	
" " " " firm	1 1	
" " " " washed and covered by the river at high water.	10 1	
	23 10	

For twenty-two miles above the point where this section was made occasional outcrops of similar rocks are exposed along the banks, but for the last ten miles they are considerably firmer and of a light yellowish or buff colour. This is well seen at the last micrometer station, 200 miles from the coast. Only one more exposure of rock was seen and that was about five miles farther up the stream, or 205 miles from the bay. These distances are given from the micrometer survey and of course follow all the bends of the river, and this makes the distance much greater than if measured in a straight line. No fossils were found in any of these rocks but in their lithological characters they resemble very closely the Devonian rocks at the Sextant rapids, Abitibi river, where there are bands of the reddish and grayish rocks which both in the ledge and in hand specimens are identical with those on the Kapiskau river. The rocks on the Abitibi underlie beds containing typical Devonian fossils.

For 175 miles up the Kapiskau river the country is as flat as it can be and not the slightest elevation is apparent. At the end of this distance, however, the character of the country somewhat changes and for the next 25 or 30 miles up the monotony is relieved by low hills 75 feet high which give a rolling aspect to the country. These hills were evidently formed by erosion and are comparatively level on the top. This area is drier as the soil contains much sand and is covered for the most part with a thick second growth of poplar and canoe-birch with many dry trunks of trees standing or lying scattered over the ground. Going west up the river, the land again becomes flat and the current is

Character of
Kapiskau
river.

not so swift or the rapids so numerous, and at 260 miles the stream becomes much broader and forms a lake-like expansion of comparatively still water for six miles, when it opens out into a small shallow lake. This lake is only one mile long and half a mile wide, but is of some importance as it gives the name to the river. When approaching this lake in a canoe there is no channel or passage visible as it is filled with tall scouring-rushes (*equisetum*) and the canoe has to be forced through these across the lake. The word Kapiskau means obstructed or blocked up and was first applied to this lake and afterwards to the river. For the next mile the river flows from the north-west in a sluggish broad stream with marshy banks, and again expands into a narrow lake running north and south for three miles. At the extreme north end, the river enters and for four miles is almost dead water, after which it has a swift current with occasional rapids as far as it was followed, a distance of seven and a half miles from the lake. At the point where I turned back the river was from 30 to 40 feet wide and in places four feet deep, while in other places there was not enough water to float a canoe. It was blocked every few chains with log jams and fallen trees which reach from bank to bank. We had to cut our way through these and this made progress so slow that I decided to return, having first climbed a tree which gave a view of the country for a long distance and nothing could be seen but a broad plain covered with ragged bush with an occasional clump of large green trees mostly spruce, poplar and tamarack, but the area within a radius of five or six miles that is so covered in any one place is small. A small stream enters the largest of the Kapiskau lakes from the west but it proved to be full of boulders, driftwood and rapids so that it could not be navigated by canoes for more than a mile.

Gravel ridge.

Half a mile west of the south end of the lake there is a ridge which, though only 75 feet above the level of the lake stands out prominently from the level country. An examination showed that it is composed chiefly of gravel. It has the form of a kame and is about 20 chains long and 500 feet wide. It is sparsely covered with Banksian pine, canoe-birch and poplar. Viewed from this elevation the whole surrounding country is a vast plain. The only rise to break the monotony is a slight elevation five or six miles to the north. There is a small lake a mile to the south and peaty swamps are common. These are covered with small spruce and tamarack, and the drier ground with second growth poplar and canoe-birch. The aneroid readings give an elevation of about 400 feet above sea level at these lakes.

Elevation.

Large areas are covered by peat bogs, especially along the upper stretches of the river and often the top layer along the almost perpendicular bank is composed of peat four or five feet thick.

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On my way down the river I examined some of the larger branches for seven or eight miles up and found the country in no way different from that adjacent to the main stream.

THE ATIKAMEG RIVER.

Mr. O'Sullivan reports that the Atikameg river, which he surveyed for 135 miles from the forks, presents the same characters as the main stream. There is a swift current and numerous rapids, and the upper part is very crooked with many short bends. The banks are composed of bedded and boulder clays and are from ten to twenty-five feet high. The forest growth, close to the river, consists of spruce, poplar, tamarack, canoe-birch and fir. The spruce averages from six to twelve inches, with occasional trees twenty inches or more in diameter. Back five or six chains, from the river banks, the land is open swamp and muskeg, covered with small spruce and tamarack. No rock exposures were seen on the lower part of this river. The first rock in place is 100 miles from the forks and is a flat-lying, honeycombed light yellowish dolomitic limestone. Some of the cavities are partly filled with a white mineral, which on exposure to the air crumbles into powder. Some of the layers are harder and have fewer cavities. A rock of this character is seen one mile and three-quarters farther up the river. Four miles and a half above this, the soft, grayish limestone, already mentioned as occurring on the main branch, was observed. Rocks similar in character to those seen at these three places occur at intervals almost as far as the river was examined. The specimens collected show that some of the strata are much harder than those of the Kapiskau river. Where Mr. O'Sullivan turned back, the aneroid gave an approximate elevation of 375 feet.

Atikameg river.

Forest growth.

Elevation.

THE OTADAONANIS RIVER.

At high water this branch is navigable for canoes almost to its source and forms a canoe route to the Albany river, by a portage connecting its head waters with the latter.

Otadaonanis river.

It is two and half chains wide at the mouth and I was able to ascend it forty-five miles, though the water was comparatively low. Its general course is north-east and it runs close to the main river as well as to its principal branch, the Atikameg. The banks are composed of clay containing the usual boulders and shells. No rock exposures were seen, but small heaps of the reddish and grayish mottled limestone were lying on the banks as if deposited there by melting ice pans, and indicate that the rock is probably in place farther up the stream.

Clay, sand
and shells.

The clays exposed along the banks of the Kapiskau and its branches show considerable variety. Near the coast an unctuous bluish-gray clay is overlaid by ordinary sandy clay. Farther up the river, typical boulder clay full of striated boulders occupies the lower part, with more or less stratified material on top. There is no sharp line of separation between them, as they seem to merge into each other. In places there are thin bands of peaty material containing plant remains. Still farther up the banks are higher and the material much more sandy and gravelly, often showing false bedding. Generally the upper layers contain marine shells with few boulders, while the lower part is decidedly bouldery. Thinly laminated limestone concretions are common, usually circular in form, but as far as examined they contain no fossils. For 125 miles up the river there is no means of estimating the exact thickness of the clay covering, but above this, where it rests upon the solid rock, it varies from ten to seventy-five feet. A section six miles above the forks gives, in descending order:—

Stratified clay.	10 feet.
Bouldery "	20 "

Bouldery
clay.

The bouldery clay is very much like the overlying stratified clay in general appearance, and is of a dark slate colour, but shows no stratification and contains no fossils.

Limestone fragments, both rounded and angular, are common in the clay; also a dark very fine grained argillaceous arkose or graywacke with spheroidal pseudo-concretions of a lighter colour, which by differential weathering are sharply outlined. The cavities thus formed vary in size from mere specks to six inches or more in diameter. In section, examined by Mr. O. E. LeRoy of this office, the pseudo-concretion is seen to consist of angular and rounded fragments of clear quartz and turbid feldspar, shreds of biotite, muscovite and brown sphene imbedded in a matrix of calcite. The centre of the area is occupied by an oval-shaped fragment of fine clay slate. No concentric structure is apparent. The main mass of the rock differs in having a clay or kaolin matrix. These boulders are the most widely distributed and probably the most numerous of all the boulders in the drift, and are found on the west coast of James bay and all the rivers examined in this vicinity. Dr. Bell states that they extend all the way south to Lake Superior and that the rock is found in place on Long island, off Cape Jones, on the East Main coast.* Besides these there are well rounded boulders of red and gray granite, gneiss, reddish conglomerate containing jasper pebbles, greenish

* Report of Progress, Geol. Surv. Can. 1886, vol. II, (New Series,) pp. 206 and 366.

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breccia containing pyrite; banded jasper, jaspilite, several iron ores of low grade; hornblende schists; diorites, &c. Some of the jaspery iron ores are identical, as far as can be judged from hand specimens, with those collected by Dr. Bell and Mr. A. P. Low on the east coast of Hudson bay, and they also resemble very closely iron ores found in situ on Sutton Mill lake by Mr. D. B. Dowling.

Iron ores
prices.

The shells, etc., found in the clays of the Kapiskau river as determined by Dr. J. F. Whiteaves, are as follows:—*Saxicava rugosa*, *Macoma calcarea*, *M. Balthica*, *Cardium ciliatum*, *Mya truncata*, *M. arenaria*, *Leda buccata*, *Mytilus edulis*, *Seripes Groenlandicus* and *Balanus crenatus*. The shells of *Saxicava rugosa* are very large, one specimen measuring one and seven tenths inches in length, and three quarters of an inch in width. The first two in the above list are by far the most common and are found everywhere. No striae were observed except on boulders as the soft rock where exposed had weathered and disintegrated.

Fossils.

JAMES BAY.

The most noticable feature of the west coast of James bay is its extreme flatness. Looked at from a distance there is no distinct shore line but the water and land seem to merge into each other. A strip varying in width from one to three miles and partly covered with grass and low shrubs, extends along the coast from the Kapiskau to the Moose river, except for a few miles north and south of Cockispenny point where the shore is fairly high and dry and the trees come to the water's edge. At this point one can land with canoes almost any time, but elsewhere the water is very shallow and at low tide, bare mud flats extend out for miles. Gravelly ridges with numerous boulders are very common and form one of the serious obstacles to canoeing along the coast.

Coast of
James bay.

At Cockispenny point I noted the reddish-brown and grayish limestone that has been already described as occurring on the Kapiskau. Farther south at Pisquochi large masses of a light gray and dark buff limestone containing the Devonian fossils *Spirifer divaricatus* and *Streptelasma prolificum* were observed. There seems to be little doubt that these rocks are in situ.

Fossils.

THE KWATABOAHEGAN RIVER.

This river enters the Moose river by two channels separated by a triangular island. The north channel is the larger, but has two bad rapids. The river is broad, shallow and rapid and flows over flat-lying,

Kwotabohe-
gan river.

fossiliferous limestone for thirty-two miles. When the water is low it is with difficulty it can be ascended, but this is much the best time to examine the rocks, as it is only at comparatively low water that the beds in situ can be seen. Near the mouth the rock is a light grayish limestone dipping S. W. $< 10^\circ$ and containing numerous fossils. Farther up it is horizontal and of a light brownish colour. These rocks resemble very closely those on the Moose and Abitibi rivers and contain the same fauna.

Fossils

The following fossils were collected from these rocks. The Brachio-pods, etc., were identified by Dr. J. F. Whiteaves and the Stromatoporoïds and Corals by Mr. Lawrence M. Lambe :—

- Stropheodonta concava*, Hall.
- Spirifer divaricatus*, Hall.
- Atrypa reticularis* (L).
- Pentamerella*, sp. indet.
- Modiomorpha*, sp. indet.
- Spathella*, like *S. subelliptica*, W.
- Conocardium cuneus*, var. *trigonale*, Conrad.
- Platystoma*, sp. indet.
- Cyclonema* (?), sp. indet.
- Loxonema*, sp. indet.
- Gomphoceras beta*, Hall.
- Orthoceras*, sp. indet.
- Phacops*, sp. indet.
- Proctus*, sp. indet.
- Portions of Crinoidal Stems.
- Diphyphyllum arundinaceum*, Billings.
- Syringopora Hisingeri*, Billings.
- Cyathophyllum exiguum*, Billings, sp.
- Cyathophyllum Halli*, Milne-Edwards and Haime, sp.
- Cladopora cryptodens*, Billings, sp.
- Actinostroma expansum*, Hall and Whitfield, sp.
- Favosites hemispherica*, Milne-Edwards and Haime.
- Phillipsastræa Verneuli*, Milne-Edwards and Haime.
- Syringopora nobilis*, Billings.

Peat.

At sixty-five miles up there is a large quantity of a solid peaty material in the bed of the river. The mass where examined was six feet thick and it can be traced along the river for 430 feet. It is of a dark brown colour and breaks off into lumps two to three feet thick. It burned slowly in the camp fire, but left a large quantity of ash, and an examination of a specimen made by Dr. Hoffmann in this office

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showed that it would be useless for fuel unless it occurs in other places much purer than the specimens examined. Thin layers of the same material are exposed in the bank intercalated with the clay for several miles up the river, but everywhere they were impure.

As stated above, this river was examined for a distance of ninety miles, and from Indian sketches and descriptions, I infer it continues westward forty or fifty miles farther, though where I turned back it was with difficulty it would be navigated with a light canoe. Rapids are common along its whole course and it was necessary to make three short portages to pass the large ones. These rapids could have been poled up if the water had been sufficiently deep.

The land along the whole course is low and swampy, and as on other rivers examined in this country, there is a dry ridge of a few chains width along the banks and then low swampy ground covered with small spruce and dead tamarack. The principal trees are spruce, the largest being from one to two feet in diameter and the average six to eight inches, tamarack mostly dead, poplar, balm of Gilead, fir and an occasional canoe-birch, and on the upper parts cedar is common. Willows and alders and other shrubs line the banks. Some of the spruces are tall and straight and would make good saw-logs or pulp wood, but trees of this kind are only seen close to the rivers. For the most part where the land is at all dry the trees are crowded together as closely as they can stand and this tends to stunt the growth of all. Patches of second growth ten to twenty years old occur along the river and there are areas of considerable size burned within one or two years.

At seventy-five miles up, the canoe route leaves the river and follows a small tributary to the north called the Agwasuk. This stream is connected by a portage of a mile across the height of land to a lake which drains into the Albany river, the stream entering the Albany near the head of Big island.

THE STOOPING RIVER.

In following this route from the Albany, Mr. O'Sullivan noted a light yellowish limestone two and a half miles from the mouth. The fossils in these rocks show that they belong to the Devonian system, probably Corniferous. This river for the greater part of its length forms a fairly good and easy canoe-route. It flows between clay and sand banks in places twenty feet high, with shells and boulders common to all this country. The adjacent country is reported to have been burned eighteen or twenty years ago, so that now there is a second growth of spruce averaging four to eight inches in diameter, with a

few small trees of poplar, tamarack and birch. Back from the river, the land is low and swampy and partly covered with the usual small trees. The two lakes near the source of the river lie in a flat swampy country the general elevation of which is about 275 feet above sea level. The largest, four miles long and two miles broad, is called Sand Bank lake and it is from it that the portage connects through an open swamp with the Moose waters. The stream into which the portage is made is small and very crooked and so overgrown with willows and blocked by fallen trees and old beaver dams that it was with the greatest difficulty a canoe could be got through, and for the twenty-three miles to the main river the stream is rough and difficult.

Clays and
fossils.

The clays, boulders and pleistocene fossils on this river are identical with those on the Kapiskau except that the local limestone boulders are more numerous in places along the Kwataboahagan. One mile from the mouth striae occur on the limestone rocks, and also a mile farther up on the south side of the first long island. The course is S. 14° W. and S. 29° W. of the true meridian. There is no distinct stossing, as the limestone lies flat, but after a careful examination I have no hesitation in placing the direction as above.

Peat beds.

Reference has already been made to thick beds of peaty material on the Kwataboahagan river and thin layers of the same kind on the Kapiskau river. Similar thin layers of the same kind were also observed along the lower Abitibi river and also a thick stratum of lignitified wood. The thin layers seem to be intercalated with stratified clay while the larger masses are overlaid by a considerable thickness of bouldery clay which forms the lower part of the surface deposits along these rivers. I was not able to penetrate through the beds of peat and lignitified wood so as to see whether they rest on boulder clay or stratified material. It seems probable, however, that they are interglacial, and if so, judging from the thickness of the beds, a somewhat lengthened period must have elapsed from the retreat of the first glacier to the advance of the next. The striae and surface deposits of the country to the south clearly point to two or more separate movements of the ice.*

Track surveys
checked.

All the track surveys made were constantly checked by astronomical observations, and in the case of the Kwataboahagan river I was able to make a paced survey of much of the lower part by walking along the banks.

*Summary Report, Geol. Surv. Can., 1901, pp. 126, 166.
Glacial and Inter-Glacial Deposits near Toronto, by A. P. Coleman. *Journal of Geology*, vol. III; No. 6, 1895.

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The latitude and magnetic declination of the following places are:—

	Latitude.	Magnetic declination.
Mouth of the Kapiskau river.	52° 45' 45"	12° 10' 25"
Mouth of the Atikameg river.	52 29 40	
200 miles up the Kapiskau river.	51 55 0	7 7 36
Fort Albany.	52 14 28	11 45 0
Cockispenny point, James bay.	52 0 0	
Moose Factory (Ogilvie).	51 14 42	
Niven's line (Moose river).		11 0 0
Sand Bank lake, north end of portage.	51 3 30	

*This latitude is the average of Mr. D. B. Dowling's and ours.

THE ABITIBI RIVER.

From the mouth to the Sextant rapid the Abitibi river is broad, rapid and shallow and studded with numerous islands, some of considerable size and great beauty. Islands in Abitibi river.

The banks are high in places, reaching thirty or forty feet and are composed of clay, sand and gravel and are well wooded with black and white spruce, poplar, fir, birch, balsam of gilead, cedar and tamarack with numerous shrubs. Above the Sextant rapid the river is narrower and deeper and has a fairly strong current. The banks are mostly clay, often high and almost perpendicular with hills rising behind to a height of 100 to 150 feet. Up to the Otter portage there is much swift water with some rapids. At this portage the river contracts to about one quarter its usual width and for nearly two miles flows through a winding gorge with high rocky walls. Looking down from the portage it presents a wild and picturesque appearance. A large area around this point was overrun by fire in 1901, both sides of the river. The Otter portage is 152 chains long. From this to the Long portage the river flows between well wooded high banks and is about fifteen chains wide. Numerous gravel terraces occur along this tract. From New Post up, the forest is second growth about fifteen years old.

The roughest part of the river begins at the foot of Long portage, above which is the belt of eruptive rocks already referred to, and continues for nearly eight miles in a series of rapids. The Long portage is 141 chains in length and has a bad hill at the north end. Across a small bay a very swift rapid is passed by the Oil Can portage, then follow Birch Bark, Clay Falls, Rocky and Lobstick portages. Birch Bark is thirty chains, and Lobstick thirty-three and a half long, Long portage.

but all the others are short. Above these rapids the river bends to the east for nearly two miles, then its course is almost south. At the last bend there is a trail which connects with six small lakes and joins the river between the Oil Can and Long portages. This route necessitates making seven portages aggregating five miles, but when the water is high the river is too dangerous for small canoes and the latter route has to be used. From this point south to Niven's base line, 1900, just below Island portage, the current is moderate and the clay and gravel banks are lined with terraces. There are rounded hills, rising to a height of 150 feet or more above the river level, and covered with small poplar, canoe-birch, spruce, fir, cedar and dead tamarack, but for five or six miles below Island portage, black spruce is the prevailing tree. Island portage is on a small island and is required to pass a rough rapid, and just south of the island there is another short portage on the west side. The rapids here, however, can be run, or poled up by ordinary canoes when the water is not too high. Numerous islands occur up to the Three Carrying Place portage and the current is rather strong. At this place there are two swift rapids with a fall of fifteen feet or more. These are passed by two short easy portages on the west side, or one rather long and difficult one on the west bank. In going up the river to the Frederick House branch two fair-sized streams are passed, Singed Martin creek and Driftwood creek. Just below the mouth of the Frederick House river a section of the main river was made, September 22, which showed that at this point it has a volume of approximately 401,000 cubic feet per minute. The width here is thirteen chains and the greatest depth seventeen feet, but the current is slow.

Section made
of river north
near mouth of
Frederick
House river.

In ascending, the river turns abruptly to the east and continues in that direction for ten miles and a half. Kettle Falls portage is on the south bank and about two miles from, the bend. Another short portage is necessary to overcome a swift rapid about midway on this stretch and for the greater part of the way to where the river turns south the current is swift and strong.

At the bend to the south, Jaw-bone creek enters, and the river from this point to the crossing of Niven's line is about ten chains wide and flows with a moderate current. This point connects with the micrometer survey made by me last summer up to Speight's trial line below the Iroquois falls.

On our way up the river we made a section between the Couchiching falls and Lake Abitibi which gave the approximate volume of the water at this point 306,000 cubic feet per minute. The width of



CLAY BANKS ON KWATAGOHEGAN RIVER, ABOUT 70 MILES FROM MOOSE RIVER.



KWATABOAHIGAN RIVER JUST BELOW THE MOUTH OF THE AGWASUK BRANCH, 1902.

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the river here is six chains and the greatest depth forty-two feet, with a slow current.

Geology of the Abitibi River.

The lower part of the Moose river flows over Devonian limestones, and the same is probably true of the Abitibi up to the Sextant rapids, a distance of seventy-two miles from the mouth.

At the mouth of the Abitibi there is a rapid, passed by a portage on the west bank. The fall is about eighteen feet over ledges of a buff coloured limestone weathering white and dipping slightly to the south-west. This rock is seen in places for five or six miles, but contains no fossils as far as examined. For the next fifty miles no rock exposures are seen, but there are deep cut banks of clay containing marine fossil shells and in the lower part many boulders. The banks are well wooded and much of the soil along the river is of excellent quality, being for the most part a rich sandy loam.

Opposite Big Cedar creek, in the west bank there are seams of impure peaty material two to three feet thick intercalated with the clay. These beds are overlaid by ten to fifteen feet of clay, in part stratified, and they are exposed at intervals for a considerable distance. Forty miles from the mouth of the river, at what is called Blacksmith rapid, there is an outcrop of lignite or lignitified wood. On the east bank we sank a hole into it to a depth of nearly five feet, when we got below the level of the river and water coming in prevented us reaching the bottom of the seam. Much of the material taken out was loose and comparatively fine and coaly, but some of it was woody and firm and showed the vegetable structure clearly. Fine seams of sand were occasionally met with in digging into the mass, but these were less than an inch thick. Many specimens of plant remains were found but they have not yet been identified. Some of the specimens collected have broken up on exposure to the air and show a bright shiny surface. About ten feet of bouldery clay overlies and covers up the bed on the sloping bank and makes it difficult to trace it for any great distance, especially in the absence of any proper instruments to dig with. The Indian guide reported that thin seams of this coaly material occur on the Kisagami river (West river, of the Northern Ontario map, 1900) below the large bend where the first portage is made. Similar exposures have been described on the Missinaibi river and its branches to the west by Dr. Bell and others.* This material

Big Cedar creek.

Lignite possibly of economic importance.

* Report of Progress, Geol. Surv. Can., 1875-76, pp. 326-327, and 1877-78, pp. 4-16. Report on the Basin of Moose river and adjacent country, by E. B. Barron, 1890.

may be of considerable economic importance as it evidently spreads over a wide area and if it can be found in large enough quantities would be a useful fuel for local purposes. In proceeding up the river thin bands of impure peat are occasionally seen close to the water level for the next fifteen miles.

Sulphur
spring

Fifty-five miles up an exposure of gray shale dipping S. 30° E. $< 10^{\circ}$ outcrops on the west bank. The topmost layers are very fissile and soft, while at the level of the water they are thicker and slightly firmer, but still soft. This is near the foot of the Long rapids, and other exposures of a similar kind are seen farther up for over three miles. A sulphur spring is situated on the west bank about a mile and a half above the first outcrop of shale and is covered at ordinary high water. Outcrops of a grayish, fossiliferous limestone are met with in the upper part of the long rapids associated with layers containing cavities partly filled with calcite crystals, and others of fine grained, evenly-banded strata. For six miles below the second portage on the river there are no rock exposures, but high clay banks. The rapid causing this portage falls about six feet and runs through a mass of porous, granular, dark-brownish limestone weathering white and holding fossil corals. The cliffs on either side are twenty feet high. On account of the abundance of the corals in the rocks at this point I propose to call it Coral rapid. Between this portage and the Sextant rapid the limestone is from yellowish to reddish-brown in colour and full of fossils, especially corals. Just below the Sextant rapid there is a high cliff on the east side of alternate hard and soft bands mostly of a grayish limestone, but containing in the lower beds the reddish-brown clayey limestone similar to that found on the Kapiskau river and at Cockispenny point on James bay. Some of the uppermost layers contain fossils.

Fossils
identified.

From the fossils collected along this river Dr. Whiteaves and Mr. Lambe have identified the following species, all indicating a Middle Devonian horizon :—

Cyrtina, sp. indet.

Atrypa reticularis (L).

Paracyclas elliptica, Hall.

Cyathophyllum Halli, (Milne-Edwards and Haime.)

Streptelasma prolifica, (Billings.)

Phillipsastraea Verneuli, Milne-Edwards and Haime.

Stromatopora tuberculata? Nicholson.

Stromatopora, sp. Cfr. *Stromatopora Hupschii* (Bargatsky.)

Favosites turbinata, Billings.

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Favosites basaltica, (Goldfuss.)

Favosites cervicornis, Milne-Edwards and Haime.

At the south end of the Sextant portage there is a layer of sandstone underlain by several feet of conglomerate, and below this, masses of a dark augite rock forming the bed of the river. Across the river on the west bank at water level there are thinly laminated gray shales containing fossil plants. Above the shales and lying conformably there are beds of conglomerate, and on top of this seemingly bedded eruptive rocks similar to those on the east bank. The petrographical descriptions which follow are by Mr. O. E. LeRoy of this office. Of specimens from both sides of the river at the above point, he says: 'The hand-specimens represent a very dark almost black augite lamprophyre of a type closely allied to the monchiquites. The section consists of aggregates of calcite and serpentine as pseudomorphs after olivine, and pale brown and pink idiomorphic augites in a ground mass of augite, shreds of biotite, calcite, chlorite, magnetite and a fibrous zeolite.'

Petrographical descriptions.

At the north end of the rapid what looks like a dyke cuts diagonally through the strata from top to bottom, but I did not make a close examination.

Strata cut by probable dyke.

About a mile south of this portage on two small islands the first Laurentian rocks are seen, where there is an exposure of reddish granitoid gneiss. The same rock outcrops at the north end of the Otter portage much disturbed and broken and intersected by pegmatite veins. This portage leads across exposures of micaceous rusty gneiss near the north end where the foliation is distinct and the strike east and west. At the south end there is a garnetiferous gneiss dipping N. 60° E. < 45 cut by dioritic dykes one to four inches wide. Several exposures of granite and gneiss striking in a general way east and west are seen along the river up to two miles from the Long portage. Here the rock is a 'pink and light gray pegmatite, consisting mainly of feldspar with subordinate quartz and biotite. The section shows an alltriomorphic structure, the feldspar (orthoclase, microcline, oligoclase) occurring in large irregular individuals with smaller grains occupying the interstices. The quartz occurs in definite areas. Limited alteration has gone on in the plagioclase, producing calcite, epidote, and zoisite, while the biotite is almost completely altered to carbonates and limonite.' At the north end of the Long portage the character of the rock changes. It is felsitic and much broken and shows irregular lines running north and south. A short distance south at the Oil Can portage the rock is an olivine hypersthene gabbro, dipping N. 45° E. < 75. 'It is a dark, rather fine-grained type, composed of black

Rocks at north of Long portage.

pyroxene and rusty feldspar, the whole having a rudely foliated structure. Microscopically the rock is composed of diallage, hypersthene, olivine, plagioclase, with accessory magnetite, pyrite and apatite and secondary serpentine. The minerals occur in polygonal and rounded forms with smooth borders. Pale gray diallage with the usual microstructure is the dominant pyroxene. The hypersthene is pleochroic in tones ranging from rose red to a faint green; the olivine is colourless and is more or less altered to serpentine. The feldspar is probably labradorite; it is twinned according to the albite law with additional pericline in some cases. With crossed nicols evidence of strain is apparent from the undulatory extinction, and the bent and broken twin lamellae. The structure is that of the eruptives usually classified as Laurentian. From the Oil Can portage to Rocky portage the rock is coarser, but a representative specimen taken two and a half miles from the last shows that the rock is an olivine gabbro. The structure is similar to that of the specimen just described but the mineral content differs in that hypersthene is absent while biotite is present. The iron ore is ilmenite with a border of leucoxene.

Rocky
portage.

At the Rocky portage there is an outcrop of well foliated rusty gneissic rock striking N. 80° W. At the south end the dip is N. < 75° with coarse pegmatite veins cutting the strike. These rocks continue up to the Lobstick portage where a garnetiferous biotite syenite rock appears. 'This is a fine grained rather basic dark red rock, holding a very large amount of garnet in grains and rhombic dodecahedra. The garnet is much cracked, and perfectly isotropic; it holds inclusions of feldspar and biotite in a poikilitic manner. The feldspar is a finely twinned plagioclase, in all probability albite. Biotite in irregular plates and idiomorphic forms with skeleton structure occupies spaces between the feldspar and garnet. A few grains of apatite and zircon complete the section. The rock from its association may possibly be referred to the Grenville series.'

A short distance above the portage, gneissic rocks again outcrop, and on an island a mile and a half distant near where the river turns south the dip is N. < 75°. No rock exposures were seen along the river for the next seventeen or eighteen miles, the first appearing a little more than half a mile below Niven's base line north of Island portage. Here the rock is a 'biotite granite or granitite, coarse grained, and made up of gray and pink feldspar, black mica and hornblende, and quartz. Under the microscope the feldspar occurs as albite, orthoclase and microcline, the former predominating. Associated with the biotite is a little pale green hornblende which includes the magnetite. Quartz, apatite, zircon and muscovite complete the

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section." On Island portage there is a slickensided rock which under the microscope proved to be a sheared portion of the above, the 'section showing a granulation and alteration of the minerals with attendant development of kaolin, chlorite and calcite.' Adjacent to this rock are masses of gneiss dipping S. E. $< 50^\circ$, but they are very much disturbed and broken up. One or two exposures of this slickensided rock are seen in the next two miles with intervening outcrop of gneiss and granite, which are the principal rocks in the river up to Niven's meridian line of 1898. At the Three Carrying Place portages on the east bank the foliation of the gneiss is very distinct; the dip is S. 70° E. $< 50^\circ$ and on the second portage ascending the river it is N. 80° E. $< 32^\circ$. At this point there are bands of almost pure quartz. One mile and a half below the mouth of the Frederick House river on the east bank there is a reddish massive granite, chiefly quartz and feldspar. At Kettle falls the gneiss is composed of alternating bands of red and gray feldspar, quartz, mica and hornblende. The dip is S. 40° E. $< 35^\circ$. A hand specimen taken at this point is a 'granitite gneiss, well foliated, light gray in colour and is one of the most acid types. The microscope shows the feldspar to be present both as orthoclase and plagioclase (albite), which occur in irregular individuals with a somewhat interlocking habit. Strain shadows prevail both in the quartz and feldspar. The biotite is in part idiomorphic, and includes or is associated with zircon, apatite, epidote and calcite.'

Two and a half miles east of Kettle falls there are numerous bands of white quartz exposed in the gneiss. One measured two and a half feet in thickness. Most of the rocks from the Lobstick portage up stream are of a decidedly acid type, but there are bands of the more basic, usually in the form of amphibolite. One of the latter is seen just below the crossing of Niven's line, where the survey ended.

The glacial phenomena of the Abitibi river up to the Sextant rapid resemble closely those on the other rivers described. Above this rapid, through the Archæan rocks, the river has a distinct valley, with many sand and gravel terraces along its banks, sometimes rising one above another. These are well seen between the Otter and Long portages where, besides low terraces near the water, usually of small area, there is one at 40 feet and another at 100 feet above the present river level. Almost as soon as the older rocks are reached signs of glaciation appear, with the stossing invariably on the north side. The general course of the striae along the river is south, but exposures vary from S. 10° E. to S. 30° W., true meridian. On the trail, coming out above the Long portage, there is a steep ridge or "horseback" a quarter

of a mile long, running N. 20° W., and a low ridge of the same character is crossed near the north end of the Long portage.

Extent of
Middle
Devonian.

The examination of the rocks on the rivers explored shows that the Middle Devonian system extends from the mouth of the Kwataboahagan river, south to a short distance above the Sextant rapid, and north probably along James bay to the Kapiskau river, and westward for a considerable distance. On the Abitibi river, from the Sextant rapid to the Long portage, the rocks belong to the Laurentian system. Then for a distance of about 8 miles the rocks, in general appearance, resemble the Huronian, but the microscopical examination of the hand specimens points to their possibly belonging to the Grenville series. South of this narrow band the formation is Laurentian, and continues the same up the river beyond the southern boundary of the map, or to within a short distance of the Iroquois falls.

CLIMATE AND GAME.

Climate.

During the months of July and August while working on the Kapiskau and Kwataboahagan rivers the weather was usually fine with warm days and cool nights. The temperature in the early morning averaged about 50 degrees and in the middle of the day 70 to 80 degrees. Thunderstorms preceded by violent gales were rather frequent. Vegetation along the rivers was very rapid and luxuriant.

Game and
fur bearing
animals.

Game was not plentiful on the Kapiskau and Kwataboahagan rivers, the few Indians who were there, living wholly on fish and rabbits. The only animals we saw in this district were two bears, three deer, a lynx, and two otters, although the Indians hunt beaver, fox, marten, mink, muskrat and weasel. A few ruffed grouse and an occasional flock of ducks and geese were seen, and the tracks of one or two moose. The Indians report that this animal is steadily moving farther north. Pike, pickerel and whitefish are found in the rivers in limited quantity and the last is caught in the bay along the coast. Sturgeon are caught in the Abitibi river, two of which I saw near Singed Martin creek.

Acknowledgments due.

Mr. Owen O'Sullivan, who accompanied me as assistant, did his work in a most satisfactory manner. I am indebted to him for material assistance in making astronomical observations with the transit, and for a number of photographs, illustrative of the geology and scenery of the country examined, as well as for aid in the general management of the work.

My thanks are due Messrs. Robert Skene, David Armit and other officers of the Hudson's Bay Company for valuable assistance; to the

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Rt. Rev. J. A. Newnham, Bishop of Moosonee, for personal kindness and to the Rev. F. Swindlehurst for photographs of the waterfalls on the Missinaibi river, etc.

The following insects were collected chiefly on James bay and the Kapiskau river in July and August, and were identified by Dr. James Fletcher of the Central Experimental Farm.

COLEOPTERA.

Carabus Mœanler, Fisch.
Pterostichus orinomum, Leach.
Adalia frigida, Schn.
Lina lapponica, L.
Lina scripta, Fab.
Monohammus scutellatus, Say.
Pissodes strobi, Peck.

LEPIDOPTERA.

Grapta j-album Bd.-Lec.
Lycæna lucia, Kirby.
Pieris oleracea-hiemalis, Harr.
Sphinx gordius, Cram.
Cosmia paleacea, Esp.
Triphosa dubitata, L.

ODONATA.

Aeschna verticalis, Hagen.
Diplax hudsonica, Selys.
Calopteryx Virginica, Drury.

List of plants collected by W. J. Wilson along the shore of James bay and in the valley of the Kapiscan river.

By John Macoun.

The species included in the first column are those collected along the shore of James bay between the mouth of the Moose river and the mouth of the Kapiskau. The second column includes the species collected along the Kapiskau river.

<i>Anemone nemorosa</i> , L ..	.....	+
<i>Anemone multifida</i> , DC. ....	.....	+
<i>Anemone Canadensis</i> , L.....	.....	+
<i>Anemone parviflora</i> , Mx .....	.....	+
<i>Thalictrum dioicum</i> , L.....	.....	+

<i>Ranunculus septentrionalis</i> , Poir	+
<i>Caltha palustris</i> , L.	+
<i>Actea rubra</i> , Willd.	+
<i>Arabis hirsuta</i> , Scop.	+
<i>Erysimum cheiranthoides</i> , L.	+
<i>Symbrium humile</i> , Meyer.	+
<i>Draba incana</i> , L.	+
<i>Viola cucullata</i> , Ait.	+
<i>Stellaria borealis</i> , Bigel.	+
<i>Alsine humifusa</i> (Rottb.)	+
<i>Arenaria peploides</i> , L.	+
<i>Astragalus alpinus</i> , L.	+
<i>Lathyrus maritimus</i> , Bigel.	+
<i>Lathyrus palustris</i> , L.	+
<i>Vicia Americana</i> , Muhl.	+
<i>Prunus Virginiana</i> , L.	+
<i>Nyctilia opulifolia</i> , Benth & Hook.	+
<i>Rubus triflorus</i> , Richards.	+
<i>Rubus arcticus</i> var. <i>grandiflorus</i> , Ledeb.	+
<i>Fragaria Virginiana</i> , Duchesne.	+
<i>Potentilla anserina</i> , L.	+
<i>Potentilla palustris</i> , Scop.	+
<i>Rosa acicularis</i> , Lindl.	+
<i>Amelanchier Canadensis</i> , T. & G.	+
<i>Mitella nuda</i> , L.	+
<i>Parnassia parviflora</i> , DC.	+
<i>Parnassia Kotzebuei</i> , Cham. & Schlecht.	-
<i>Ribes setosum</i> , Lindl.	+
<i>Hippuris maritima</i> , Hellenius.	+
<i>Epilobium spicatum</i> , Lum.	+
<i>Aralia nudicaulis</i> , L.	+
<i>Cicuta maculata</i> , L.	+
<i>Hieracium lanatum</i> , Mx.	+
<i>Cornus Canadensis</i> , L.	+
<i>Viburnum pauciflorum</i> , Pylaie.	+
<i>Cornus stolonifera</i> , Ex.	+
<i>Lonicera involucrata</i> , Banks.	+
<i>Lonicera glauca</i> , Hill.	+
<i>Linnaea borealis</i> , Gronov.	+
<i>Galium boreale</i> , L.	+
<i>Erigeron Philadelphicus</i> , L.	+
<i>Erigeron hyssopifolius</i> , Mx.	+
<i>Antennaria pulcherrima</i> (Hook).	+
<i>Archilaea millefolium</i> , L.	+
<i>Pyrethrum bipinnatum</i> , L.	+
<i>Artemisia vulgaris</i> , L., var. <i>Tilesii</i> , Ledeb.	+
<i>Petasites sagittata</i> , Gray.	+
<i>Arnica Lowii</i> , M. H. M.	+
<i>Scnecio palustris</i> , Hook.	+
<i>Scnecio aureus</i> , L.	+
<i>Scnecio Balsamita</i> , Muhl.	+
<i>Taraxacum alpinum</i> (Koch).	+
<i>Taraxacum officinale</i> , Weber.	+
<i>Vaccinium Vitis-Idaea</i> , L.	+
<i>Vaccinium Canadense</i> , Kalm.	+

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<i>Arctostaphylos Uva-ursi</i> , Spreng.	+
<i>Kalmia glauca</i> , Ait.	+
<i>Pyrola rotundifolia</i> , Mx.	-
<i>Pyrola asarifolia</i> , Mx.	-
<i>Pyrola chlorantha</i> , Swartz.	+
<i>Pyrola secunda</i> , L.	-
<i>Moneses uniflora</i> , Gr.	-
<i>Trientalis Americana</i> , Pursh.	+
<i>Gilauz maritima</i> , L.	-
<i>Mertensia paniculata</i> , Don.	+
<i>Castilleja septentrionalis</i> , Lindl.	-
<i>Pedicularis Groenlandica</i> , Retz.	-
<i>Rhinanthus Crista-galli</i> , L.	+
<i>Pinguicula vulgaris</i> , L.	-
<i>Brunella vulgaris</i> , L.	+
<i>Rumex Britannicus</i> , L.	-
<i>Polygonum viviparum</i> , L.	+
<i>Sacpherdia Canadensis</i> , Nutt.	+
<i>Comandra livida</i> , Rich.	-
<i>Alnus incana</i> , Willd.	-
<i>Alnus viridis</i> , DC.	-
<i>Betula glandulosa</i> , Mx.	+
<i>Populus balsamifera</i> , L.	-
<i>Salix rostrata</i> , Rich.	+
<i>Juniperus nana</i> , Willd.	+
<i>Corallorhiza innata</i> , R. Br.	-
<i>Habenaria dilatata</i> , Gray.	-
<i>Habenaria obtusata</i> , Rich.	-
<i>Orchis rotundifolia</i> , Pursh.	-
<i>Cypripedium acule</i> , Ait.	-
<i>Cypripedium pubescens</i> , Swartz.	-
<i>Cypripedium passerinum</i> , Rich.	-
<i>Calypso borealis</i> , Salisb.	-
<i>Sisyrinchium angustifolium</i> , Miller.	-
<i>Maianthemum Canadense</i> , Desf.	-
<i>Smilacina stellata</i> , Desf.	-
<i>Allium Schoenoprasum</i> , Linn.	+
<i>Lilium Philadelphicum</i> , Linn.	-
<i>Tofieldia glutinosa</i> , Willd.	-
<i>Triglochin maritimum</i> , L.	+
<i>Scirpus maritimus</i> , Linn.	-
<i>Carex maritima</i> , Muller.	-
<i>Carex lanuginosa</i> , Michx.	-
<i>Hierochloa borealis</i> , R. & S.	-
<i>Calamagrostis hyperborea</i> , Lange.	+
<i>Festuca ovina</i> , Linn.	+
<i>Hordeum jubatum</i> , Linn.	+
<i>Elymus mollis</i> , Trin.	-
<i>Elymus distachyon</i> , Trin.	+
<i>Botrychium Lunaria</i> , Swartz.	-
<i>Botrychium Virginianum</i> , Swartz.	-

GEOLOGY OF THE BRUCE MINES DISTRICT.

Mr. E. D. Ingall.

Work done by
Messrs. Ingall
and Denis.

At the beginning of June, field work was begun in the Bruce Mines District, Algoma, Ontario. Mr. Theo. Denis accompanied Mr. E. D. Ingall, who had charge of making a study and a detailed map of an area some twenty miles square, embracing a district which is important from an economic standpoint, on account of the attention now being given to its copper deposits, and also from the presence of iron ore. The area comprises the townships of Plummer, Johnson, Tarbutt, Laird, McDonald, Meredith, Aberdeen, Kehoe, McMahon, Chesley add and a portion of the Garden River Indian reserve. The object was to study, as far as conditions allowed, the relation of the mineral deposits to the inclosing rocks and their modes of occurrence; also to verify and correct the geological mapping as given in the atlas accompanying the Geology of Canada of 1863. Mr. E. D. Ingall undertook the careful study of limited mineralized areas, investigating their lithology, the manner of deposition and the exploitation of their mineral deposits in detail, and to Mr. Denis was assigned the work of the mapping of the general distribution of the rocks of the district and the topography required for the construction of a map. As there were no maps of the district available, on a convenient scale, the greater part of the season was devoted to topographical work. All the roads were surveyed with micrometer and railroad compass, some 250 miles being covered. The rock-exposures along these roads were also located, thus affording a good skeleton of the geology, which however, requires additional work to fill in the gaps before completing the map. Towards the end of the season, Mr. Denis joined Mr. Ingall and assisted in carrying out the investigations at the several points which had been chosen for detailed geological work.

The district under consideration, forms part of the typical Huronian area, studied and mapped out by Alex. Murray in the early days of the Geological Survey of Canada. The map, on a scale of eight miles to the inch, in the atlas which accompanies the Geology of Canada, 1863, gives a good idea of the general distribution of the rocks; but as the material for the construction of the map was gathered at a time when the country was bush-covered and travelling through it difficult, it can be easily understood that the geological lines require correction in places, in the light of later observations carried out under more favourable conditions.

General
geology.

The sequence of the rocks of the Huronian series, as observed by Murray, together with his descriptions, will be found in the Geology of

Canada, 1863, but since then, some of the members of the series have been the object of more thorough investigation. One of the prominent features of the formation is the 'slate conglomerate,' which has been divided in the Geology of Canada into two members, the lower and the upper. The aggregate thickness of this rock has been estimated by Murray to be over 4,000 feet. It is similar to the 'breccia conglomerate' of the Temiskaming region, which has been the subject of thorough investigation by Dr. Barlow of this department. This is well described in his report on the Temiskaming region. (Ann. Rep. of the Geol. Surv. vol. X. pt. I.) Dr. Barlow believes it to have had a pyroclastic origin. The following is an abstract of his description. 'The rock is composed of a groundmass or matrix in which are embedded pebbles and fragments of biotite granite or granitite, hornblende granite, diabase, diorite, &c. These vary greatly in size from small grains to boulders of fifteen inches in diameter and even larger. They are very unevenly distributed throughout the groundmass, sometimes in aggregates, the individuals being very close together, whereas in other places they are very sparsely disseminated, leaving between them wide interspaces of the groundmass. The granitite fragments are by far the most abundant. This material is usually of a pink colour and coarse in texture. A thin section prepared from one of the pebbles shows the rock to be greatly decomposed and to consist of orthoclase, which predominates, with plagioclase and microcline. The feldspar is much decomposed, consequently turbid and filled with sericite, epidote and calcite; the bi-silicates are almost entirely altered to chlorite. The quartz is of the ordinary granitic variety; it has a somewhat wavy extinction, but does not show other proofs of having undergone great strain. Hornblende and biotite were probably originally present but have been totally altered to chlorite.'

Slate conglomerate.

The other rocks represented by pebbles in the groundmass have also been studied; the diabase fragments are fine-grained and show much decomposition. There are also present fragments of greatly crushed and stretched feldspathic quartzite.

The matrix or groundmass in which these pebbles and fragments are embedded was found by Dr. Barlow to consist mainly of granitic debris, the fragments as a rule being simple minerals with angular or irregular outlines, indicating that they were not subjected to the trituration usually shown by constituents of ordinary clastic rocks. The minerals represented, as a rule, are orthoclase, plagioclase, microcline, with chlorite, sericite, epidote and zoisite, as well as magnetite, ilmenite and pyrite; quartz is also present, frequently showing pronounced uneven extinction.

Quartzites.

This breccia conglomerate is underlain by a series of quartzites, felspathic in character, the textures of which vary considerably from very fine grained, in places vitreous quartzites, to coarse grained, almost conglomeratic in appearance. Overlying the breccia conglomerate is another group of quartzites, the lower members of which are also felspathic. This arkose character gradually disappears and the upper members are vitreous non-felspathic quartzites ranging in colour from dark purple to perfectly white, containing in one case the red jasper pebbles which give rise to the red jasper conglomerate.

This series of quartzites overlying the breccia conglomerate has been divided into several individual members by Murray, who has mapped out their distribution with sharp boundaries. These contacts in the field, wherever observed last summer, were however not found to be very well defined, but seem to be more of the nature of a merging of the rocks into one another, the character of the strata changing gradually.

Igneous rocks.

The district is traversed by belts of igneous rocks which differ greatly in importance, varying from quite small areas to others many square miles in extent. The different areas vary considerably also both in mineral constitution and texture. They are mentioned in the 'Geology of Canada,' but are not defined on the map of the Huronian region which accompanies it. As the mineral deposits of the district seem to be largely connected with these rocks, it would be important to delimit them and study them more closely than could be done in the general examination made of the district. As a beginning towards this, some forty thin sections of specimens collected last summer are being made and will be examined as soon as they arrive.

These igneous rocks are referred to in the Geology of Canada as overflows. Although the definite conclusion as to their being so or not cannot be arrived at without more field investigation, yet the evidence gathered so far would certainly in most cases assign to them an intrusive rather than an overflow character.

Ores.

The region has received attention chiefly on account of occurrences of copper ores, although some properties have been prospected for iron ores. The copper occurs in the form of sulphides, the common ore being chalcopyrite. Bornite occurs intermixed with the chalcopyrite in the ore, especially in the surface zone.

Within the area examined, the points at which most work has been done and which were therefore selected for especial studies of the mode of occurrence of the copper ores were The Bruce, Wellington and

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Huron Copper Bay, the Rock Lake, the Cameron and the Richardson mines. Besides these, a number of other properties were examined where only surface prospecting had been done.

By far the most extensive developments made are those of the mines in the vicinity of Bruce Mines on the shore of Lake Huron, about thirty-five miles east of Sault Ste. Marie, Ontario.

Bruce and
Wellington
mines.

Although these mines were recently reopened, their history dates back over half a century, work having been commenced in 1846. The mines are situated on a group of veins whose outcroppings, showing first on the shore at a point about a mile east of the dock at Bruce Mines, have been traced for over a mile and a half in a general north-westerly direction to the limit of the workings of the Huron Copper Bay mine.

The veins are unquestionably fissures in an extensive area of 'greenstone.' The final decision as to the exact nature of this igneous mass and its relationship to the surrounding sedimentaries is a matter requiring further work in the field and microscopic examinations of the rock specimens brought in. However, as the result of a preliminary examination of a couple of thin sections by Dr. A. E. Barlow, petrographer to the department, the rock would appear to be uralite diabase. A number of dykes of a more compact diabase cut both the general mass of the older rock and the series of veins.

The area of diabase above mentioned shows a width in a northerly and southerly line of about a mile from the shore line to where the sedimentary rocks of the series first appear. No boundaries were located to its extension east and west, as it passed outside of the area under study. The large islands closing in the mouth of Bruce Mines bay are also 'greenstone,' but the shores of the western end of the bay being drift covered it could not be determined whether or not they connect with the main area of the mainland to the north. There seems to be a possibility that a belt of quartzite may intervene which has determined the erosion of the hollow now forming the bay.

Islands of
greenstone.

On the northern side this greenstone is followed by quartzite with which is associated a thin bed of impure limestone. Near the westerly workings of the Huron Copper Bay mine this limestone bed seems to be cut off abruptly by the greenstone, although the actual contact must be in the low ground intervening between the exposed surfaces of the two rocks. The limestone can be traced pretty continuously in an easterly direction to the edge of the area examined.

Only at one place however is the actual contact exposed, a wide stretch of drift intervening as a rule. At the point above mentioned the contact seems to be distinctly an intrusive one, tongues of the greenstone cutting the limestone. Much more precise exploration would be required however to decide whether these represented tongues of a dyke cutting both rocks, and younger than both or whether thereby the intrusive nature of the whole mass is to be considered proved. Passing easterly from this point, which is near the road between the village and the Canadian Pacific Railway station, it is found that a comparatively thin bed of red and dark brown quartzites intervenes between the greenstone and the limestone, the latter showing as a little ridge. Between this ridge and the rock exposures of slate conglomerate along the railroad, about half a mile to the north, the section is practically all drift-covered in the vicinity of the road. Search would have to be made therefore in the bush-covered lands east and west of this point for more continuous exposures in order to work out the actual succession of the sedimentaries lying to the north of the igneous area in which the mines lie.

Without attempting to settle these yet outstanding questions the main features of the economic deposits at this point may be summed up as presenting a series of large fissure veins cutting an extensive mass of 'greenstone,' the latter being bounded on the south by the waters of Lake Huron and on the north by the quartzites, limestone and slate conglomerates of the Huronian series.

In an easterly direction the southern limit of the greenstone is shown toward the bottom of the eastern lobe of Bruce Mines bay, where the white quartzite of Murray's map comes in. The quartzite is continuous along the eastern shore of the Bay, where, however, it is seen to be cut by numerous basic dykes.

The sedimentaries of the series are seen everywhere in the vicinity of this group of mines to dip at low angles toward the north. Along the shore of Lake Huron, however, westerly from Bruce Mines bay, the dip is southerly, exhibiting thus the other side of the anticlinal fold described and mapped by Murray.

Nature of
veins worked.

The veins worked in this group of mines consist, as previously stated, of fissures. They carry the copper in the form of different sulphides, chiefly chalcopyrite, in a gangue of quartz. At places the gangue is partly dolomitic, but the former mineral is very largely predominant as evidenced by the material of the waste piles around the workings. Near their outcrops, the veins are said to have carried a higher percentage

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of copper than below, owing to the presence of bornite and other rich sulphides of the metal. The presence of these minerals is probably due, as would elsewhere appear, to secondary enrichment.

A preliminary examination of the lower levels of the Wellington and Huron Copper Bay workings showed chalcopyrite with some pyrite disseminated through a gangue of white quartz. In the Wellington and Huron Copper Bay mines, the veins have been worked out to great widths, excavations often reaching widths of 25 to 30 feet. Of course there are many places where the veins narrowed down to not more than four feet in thickness, but ten feet might perhaps be accepted as an average of the thickness all the way through. At the old Bruce mine the veins are seen to be narrower and in the main workings would not average possibly more than five feet.

Old mines
described.

The total length attained in the Bruce workings would measure about 2,000 feet, whilst the combined length of the Wellington and Huron Copper Bay mines would measure nearly 2,500 feet. The workings at the Bruce attained depths of 250 to over 300 feet and at the Wellington the average of the depth attained in the workings would be about the same although Bray's shaft was put down to about 1,060 feet. The area of the veins stoped out, as shown on the old plans, would measure approximately as follows, viz.:—At the Bruce Mine about 225,000 square feet which, assuming a depth of 300 feet for the mine, would represent a length of, say 750 feet of vein excavated. At the Wellington, etc., a total measurement is shown of about 600,000 square feet, which would represent for a depth of say 300 feet, an equivalent in length of 2,000 feet. In both cases, it must be born in mind that these represent workings on two main veins close together and parallel to each other as worked in these two mines. In the Wellington &c., mines, these were known as the New Lode and Fire Lode. They paralleled each other for about 1,300 feet, but joined together to form a single vein at the east and western ends of the workings.

The westerly part of the Bruce workings are situated on the main lode and its branches for about 1,300 feet, whilst east of this, for about 600 feet, the chief excavations are on two veins, known as the Trial and Dodge veins. A good deal of prospecting work was done on minor veins and branches in the vicinity of these two chief mines, and also in veins which outcrop in the 4,000 feet of distance intervening between the Bruce and Wellington workings, but much more development will need to be done before the question as to the practical continuity of the series of fissures and their profitable nature can be

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Copper Co'y.

settled. An excavation called Taylor's shaft, from which it was said some test drifts were run, was sunk about midway of the distance between the two mines, but no details are available as to the results attained. The particulars given above refer to the work done during the first period of the history of these mines by the West Canada Copper Company and its predecessors. This period ended with the final cessation of work in 1876. When this company was working at its strongest it employed as many as 380 men, and for the period of years from 1858 to 1875 produced about 37,378 long tons of concentrates having a total content of nearly 7,500 long tons of copper, valued at over \$2,900,000. The average price received for the copper during this whole period of eighteen years would thus be somewhat over 17 cents per pound. Since 1858, however, the price of this metal has fallen off considerably. In that year the company obtained an average of 21 cents per pound for its copper, whereas the figures for 1875 show an average value for their product of less than 16 cents per pound. When the present company bought the mines a few years ago it reopened them and some further work was done, of which, however, we have as yet no complete data. At present nothing is being done other than to keep the plant and mines in order. In connection with the operations of the present company, the mines have been fully re-equipped with modern machinery for mining and ore-dressing, the mill having a capacity of 400 tons per day. As it is intended to give full particulars of this important group of mines in the complete report to follow later, nothing further need be stated here.

The final failure of the first attempt to work these mines seems to have been due to a variety of causes, many of which have ceased to be operative with the progress of opening up of the district, and it becomes a question as to whether successful work could not again be carried on with careful management and the improved plant and methods available.

Rock Lake
mine.

The Rock Lake mine is situated some fourteen miles north of Bruce Mines village. It is equipped with a complete mining plant, including hoists, air compressor, drills, etc., and with a mill with a capacity of 100 to 125 tons per 24 hours. The latter is situated on the shore of Rock lake, nearly two miles west from the main shaft with which it is connected by a tramway. Transportation is afforded from the mill by the Bruce Mines and Algoma Railroad, which connects with the Canadian Pacific Railway at Bruce Mines station, with an extension to the lake shore at Bruce Mines village.

The ore consists of chalcopyrite with some bornite, &c., in a gangue consisting mostly of white quartz with which is intermixed at places

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a good deal of ankerite, the ochreous decomposition product of the latter constituting a marked feature of the outcroppings at places. The developments made are situated along what appears to be a shattered zone at the contact of the red quartzite and the 'upper slate conglomerate' of Murray. The quartzite proper extends for a width across the strike of about a mile southerly, and the 'slate conglomerate,' etc., about an equal distance northerly. The workings are situated along a narrow subsidiary valley about half way up and running lengthwise of the hills of slate conglomerate flanked with quartzite which rise to a height of some 400 or 500 feet above the level of Rock Lake. In the vicinity of the mine buildings and main workings the width of the zone of shattered quartzite exposed is from 500 to 700 feet. Passing northward, this is followed by a belt of green schistose rock, showing a width of outcrop of about 400 feet. For about 400 feet further there are no rock exposures until the foot of the northern ridge is reached, where the typical 'slate conglomerate' emerges abruptly from beneath the cover. This belt exhibits the characteristic features elsewhere found of well rounded pink boulders and pebbles of granitic rock, &c., scattered throughout a dark greenish-grey matrix of slaty appearance.

The veins worked in the main shaft and connected workings are in the schistose belt. Other less extensive workings to the south of these are in veins in the shattered quartzite zone. It seems probable that the schistose belt above mentioned represents merely a portion of the 'slate conglomerate' in which schistosity has been developed by the disturbing force that at the same time produced the series of veins and shattered the adjacent quartzite.

The general dip of the formation is southerly about 25° although near the mill there is evidence of a somewhat steeper dip in the flanking quartzite, followed in ascending the hill northward by a flat anticlinal and synclinal fold before reaching the main ridge of slate conglomerate.

A comparatively small dyke of greenstone, measuring from 100 to 150 feet in width runs with a general north-westerly strike roughly parallel with the general trend of the veins. It lies about 100 feet to the south of the main shaft, and at the west end passes close to the north side of the mill. The developments made up to October, 1902, consisted of the main shaft and workings together with a considerable amount of surface development for a distance of some 1,500 feet east and a number of test pits, &c., along the same general direction westerly for about a mile and a-half. At the most of these points ore has been

exposed showing chalcopyrite disseminated through a quartz or quartz and ankerite gangue. Of the relationships of the veins to those worked in the main shaft, nothing could be definitely stated without still further detailed mapping and study, owing to the disturbed condition of the formation previously alluded to.

The main shaft, which is practically vertical, at the date of the last visit made had attained a depth of 400 feet. From it, levels had been driven east and west at depths of 100 feet and 200 feet, testing the vein for a length of nearly 600 feet. At the bottom of the shaft a small crosscut to the south reached the main vein at about 35 feet, which had been followed west in a drift for about 30 feet. The ore mined was being taken from above the second level, the stopes exhibiting a width of about 20 feet.

Apart from the small dyke already mentioned, the only intrusive rocks anywhere in the vicinity are represented by two considerable ranges of greenstone traversing the sedimentaries at distances of half a mile north and south of the mine respectively and with a general trend parallel to that of the formation.

Cameron
mine.

About two and a half miles north-east from Desbarats station on the Canadian Pacific Railway (Algoma branch) is the mine known as the Cameron or Stobie. At this place a fissure vein is seen cutting a ridge of red quartzite. On this vein a shaft has been sunk some 150 feet in depth from which, at 100 feet down, have been run drifts east and west totalling in length about 150 feet. The outcropping of the vein to the east of the shaft is not visible, being covered, but it has been stripped west of the shaft for a distance of 150 feet, where it runs under the deep soil of the adjacent farming land of the valley. Seventeen hundred feet further west on the rocky ridges opposite the mine, small surface workings have also shown the existence of ore. These are roughly on the strike of the Cameron mine vein, but whether they are to be taken as representing its actual extension or not is doubtful. The outcroppings near the shaft show a composite vein of about four feet in width, the ore being chalcopyrite in a gangue of white quartz. Some specimens show plainly surface change of the chalcopyrite to bornite. The vein in the workings shows a dip of 75° to the south and a width at places of about 12 feet made up of subordinate branches with 'horses' of quartzite.

Following the quartzite ridge southerly for about 700 feet, several small greenstone dykes cut across the quartzite in a direction roughly parallel to that of the vein. About 600 feet north-easterly from the

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shaft a coarser greenstone outcrops in one or two places, about on the run of a belt of the same rock visible in the ridges on the other side of the valley, where it shows a width of at least 125 feet. If this belt is actually continuous underneath the soil of the valley, it would thus pass about 400 feet north of the vein and with a course generally parallel to it, whilst the smaller dykes before mentioned would probably represent tongues connected with it.

The mine is equipped with power drills, hoist and pumps suitable for carrying on development work.

The workings known as the Richardson mine are situated about two miles and a half north of Desbarats village near the south-east end of Desbarats lake. These consist of a small prospecting shaft and a number of shallow pits and trenches extending over a distance of about three-quarters of a mile along the strike of a series of greenstone dykes which cut the jasper conglomerate of the sedimentary series. The evidences of the intrusive nature of the greenstone are here very marked, long narrow strips and lenses of the jasper conglomerate being included in the igneous mass. Some of the mining work done here is altogether in the greenstone, as in the case of the before-mentioned shaft. Here, as so frequently observable elsewhere in the district, the rock is much decomposed and the resulting ochreous material has stained it, giving a very tempting ferruginous appearance, whilst in the jointing, etc., it has at times consolidated to form fairly good hematite ore.

Most of the trenching and test-pitting east of this shaft has evidently been done with a view to the examination of the contacts along these inclusions of jasper conglomerate. At all the points uncovered, the ochreous material and stain were much in evidence and at some points a little chalcopyrite with malachite stain shew the presence of copper in small quantity.

The Stobie iron mine is amongst the older discoveries of the district. It is situated near the western end of Gordon lake. The openings made consist of a rock-cut in a ridge of white quartzite, run in to catch a small vein of hematite averaging about five feet in width. In the face of the bluff the vein in going upward splits into two branches, each about three feet thick. On the bare rock-surface of the top of the ridge it seems to be represented only by a number of small stringers of ore. From the end of the open cut, a tunnel has been run in, but this is now closed by a cave in at a distance of about 30 feet from the mouth.

It is said that several thousand tons of good ore were shipped from this opening many years ago, a statement which is borne out by the existence of a stope above the tunnel, measuring about 80 feet in length by 50 feet in height, and having a width varying from 3 to 8 feet.

The quartzite has a strike at this point of N. 55 W., and dips about 45° to the south at the bottom of the ridge, curving over, however, till the dip flattens out to about 20° on top. About a quarter of a mile to the north, an east and west ridge of greenstone rises up, representing evidently an intrusion through the quartzites.

At a number of other points in the district exploratory work has been done on ferruginous outcroppings of a somewhat similar nature, either in the greenstone or in the inclosing rocks near the contact. These places show all grades of material from ochreous stained rock to the consolidated ochreous product constituting specimens of good hematite. At none of the points visited, however, had any large bodies of iron ore been proved to exist.

THE SUDBURY MINING DISTRICT.

Dr. Alfred E. Barlow.

Work by Dr.
Barlow.

From the first of the year until the beginning of field operations on June 6, Dr. Barlow was engaged in making detailed petrographical examinations of rock specimens collected by some members of the staff as well as of the large suite of type specimens taken as illustrative of the various formations met with in the geological examination of the Sudbury mining district during the preceding season. In addition to these, determinations and descriptions were furnished of some of the specimens collected by Messrs. W. F. Robertson and H. Carmichael of the British Columbia Department of Mines.

Map.

When this work was finished, Dr. Barlow left for Sudbury with instructions to complete as far as possible the general geology in the vicinity of the southern nickel belt, and also to do such detailed work in connection with the Canadian Copper Company's mines as would serve to illustrate on a map of comparatively large scale, the occurrence of these justly celebrated deposits of nickel and copper ores. It is now intended to publish two maps engraved on copper, showing in a general way, the geographical distribution of the various rock-types and formations encountered. These, in accordance with our usage, will be called the 'Victoria Mines Map' and the 'Sudbury Map.' The details of the work in the vicinity of the Canadian Copper Company's

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mines at Copper Cliff, will be shown in two sheets, each on a scale of 400 feet to an inch, extending from the vicinity of Kelly lake and the Evans mine northward to the Lady Violet mine and the Manitoulin and North Shore Railway. Another but smaller sheet on the same scale will exhibit the geological relations of the deposits known as the Elsie and Murray mines. Mr. O. E. Leroy, M. Sc., of McGill University, assisted me in both the geology and topography.

Work by
O. E. Leroy.

The geological history of the Sudbury mining district, as revealed by the rocks now exposed at the surface, evidences volcanic action on a large scale, accompanied to a certain extent, and followed largely by the deposition of ordinary aqueous sediments in a shallow ocean. The rocks represent the Huronian period, and are the oldest known clastics with which geologists are at present familiar. Classified petrographically they are as follows:—

1. Quartzite.
2. Tuffs.
3. Breccia or agglomerate.
4. Greenstone.
5. Gneiss (micropegmatite).
6. Granite.
7. Olivine diabase.

Rock types.

1. Quartzite.

Macroscopically these rocks are massive, though distinctly stratified, of a pale gray, reddish, yellowish gray, or greenish gray colour. They are intimately associated with, and often inter-bedded with the tuffs and breccias, so that it is frequently impossible to separate the two in mapping them.

Macroscopic
characters of
quartzite.

Under the microscope the thin sections exhibit a rock made up chiefly of quartz, with a somewhat smaller proportion of feldspar, most of which is unstriated, and therefore presumably orthoclase. Occasional grains of microcline were noticed showing, the characteristic fine 'cross-hatched' twinning or 'fenster' structure. Much of the feldspar is decomposed into muscovite (sericite) occurring in irregular pale yellowish or colourless scales and plates and which, together with fragments of undecomposed feldspar and finely divided quartz, make up a matrix in which the larger individuals of quartz are embedded. The structure of the rock is for the most part interlocking, but some speci-

Mineralogical
composition of
quartzite.

Distribution
and stratigra-
phical position
of quartzite.

mens show distinct clastic structure, while in most the resemblance to well authenticated recrystallized clastics is such as can hardly be mistaken. A little chlorite, biotite, calcite and leucoxene are also usually present. These quartzites are at the summit of the clastic series of the district. To the north-west of Sudbury they occur in very massive beds, the lines of stratification being either very indistinct or altogether absent. A careful examination of the whole belt shows that it forms a synclinal basin resting upon the steeply dipping tuffs or ash rocks which underlie the greater part of the town of Sudbury. Nearly all of the exposures of the clastic rocks in the south-eastern part of the township of McKim and the whole of the township of Neelon belong to the quartzite series. On Ramsay lake they overlie the breccia or agglomerate exposed along the northern shores of the lake.

2. Tuffs.

Tuffs or
greywackes.

Colour and
structural
features.

Mineralogical
composition.

The rocks thus named, and concerning whose volcanic origin there is now but little doubt, have hitherto been often described as phyllites, mica-schists, felsites and greywackes. They evidently represent the consolidation of what was originally volcanic ashes, being one result of the volcanic action to which is due the presence at the surface of the great belts of greenstone and micropegmatite. These rocks are usually of a dark gray, purplish brown, or greenish-gray colour. They are often evenly and very distinctly banded in varying shades of gray. Jointing is very frequent and also slaty cleavage. They are often faulted and shattered, and in the vicinity of the various greenstone masses are penetrated and altered by irregular tongues and masses of the basic igneous material. They are frequently porphyritic and usually the phenocrysts are small, very thickly disseminated and of a very pale greyish or whitish colour. For this reason the rock has been referred to in the field as 'rice rock.' These phenocrysts were probably andalusite, but the skeleton-forms are now occupied by a confused aggregate of minute sericite scales and quartz. Other exposures show small yellowish brown spots made up of rutile, while others again show irregular phenocrysts of hornblende, now wholly replaced by chlorite. Thin sections examined under the microscope reveal a rock which has undergone rather extensive decomposition. It is usually made up very largely of feldspar with a smaller proportion of quartz in small angular or slightly rounded fragments. These are surrounded by a network of sericite and chlorite scales, together with a considerable amount of opaque iron ore. The larger individuals at least have evidently been ilmenite, but are now almost completely altered to leucoxene. The darker bands are made up of

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more thickly disseminated dust-like particles of iron ore, much of which at least is ilmenite.

3. Breccia or Agglomerate.

Perhaps the most interesting type in the district is a very distinct breccia made up of volcanic ejectamenta in the form of glass fragments of all shapes and sizes associated with some crystals or crystal fragments. This rock was very fully described by Professor G. H. Williams.* It is closely related to the other breccias of the district, which although showing rather clearly their close genetic relations with the widespread and long-continued volcanism are nevertheless largely made up of material which shows unmistakable evidence of water action. There are, therefore, the several varieties exhibiting gradations from the massive structureless types, the direct result of explosive action, to some which have been very evidently modified and rearranged by water. Such rocks are as a rule of a dark gray colour with the disseminated angular, subangular, or rounded fragments chiefly of quartz, granite, diorite, etc. Thin sections exhibit a rock made up of fragments chiefly of quartz, but also of orthoclase, plagioclase and microperthite. The most abundant composite fragments are granitite, composed mainly of microperthite and quartz together with a little biotite. All of the larger individuals are embedded in a matrix made up of much finer pieces of quartz and feldspar, together with biotite, sericite and a pale green chlorite. Occasional grains of pyrite and also some of ilmenite occur. These breccias lie at the base of the series, usually passing gradually upward into the finer-grained and usually banded tuffs above. The vitrophyre tuff or volcanic breccia, described by the late Prof. Williams, is well exposed in the north-eastern part of both the Victoria Mines and Sudbury maps, extending from Vermilion to Whitson lake. Excellent exposures of the last mentioned breccia may be seen along the line of the Canadian Pacific Railway, immediately east of Sudbury and in the vicinity of the north shore of Ramsay lake.

Description
by Prof.
Williams.

Composition
of breccia.

Stratigraph-
ical position.

Distribution

These various rock-formations in the district, must in my opinion, be regarded as all belonging to one geological system. In the region to the south-west, similar strata have been referred to the Huronian by the earlier Canadian geologists, and in the present state of our knowledge I see no good reason to abandon this view. Of course, as yet, no particular evidence has been secured or reason advanced, why these rocks should not be regarded as very early or non-fossiliferous Cambrian, which by reason of their proximity to large masses of plutonic igneous material, have been subjected to more or less disturbance and alteration.

Formations
belong to one
system.

* In report by Dr. Bell, Annual Report Geol. Surv. Can., Vol v., (N.S.) 1890-91, p. 75, F.

On the other hand, there is very little to justify the attempt at a separation into Huronian and Cambrian, as was done on the map published by the Canadian Geological Survey in 1891, since it has now been very certainly ascertained that no pronounced geological break or hiatus, such as is present in other districts at the base of the Cambrian, occurs anywhere in this region. The succession from the felspathic sandstones, quartzites and slates of the Huronian into the black slates and tufaceous sandstones, classified as Cambrian, shows a quiet uninterrupted transition with perfect conformity between the component beds or strata. Their disassociation as Huronian and Cambrian, respectively, was at the first based partly on the resemblance of these black slates to similar rocks in the Animikie of the Lake Superior district and their comparatively unaltered character. The description of this large area on the map of the Sudbury mining district was only intended to be provisional, and the precaution was taken of expressing the uncertainty of the correlation by placing the query mark in the legend accompanying the map. As usually happens, however, in such cases, this mark of doubt was removed in subsequent official maps and reports published elsewhere apparently through ignorance, without any further attempt at fuller and more critical examination and study.

4. Greenstone.

Three main
types of
greenstone.

Under this convenient field term are included certain basic igneous rocks, many of which have undergone extensive metamorphism, so that in certain cases even the closest scrutiny under the microscope, fails to reveal the original form. Microscopical examination has, however, shown the existence of three main types, although all possible transitions between these are represented in the region :

- (a.) Norite.
- (b.) Diorite.
- (c.) Amphibolite.

Norite.

The least altered phase of these rocks is represented by what may be referred to as a norite. The late Prof. Williams described the rock under the name of 'quartz-hypersthene-gabbro with accessory biotite,' but from the descriptions of the field relations furnished to him, he failed to realize that he was really examining a very fresh representative of the country rock of the nickel and copper-bearing sulphides.

Mineralogical
composition
of norite.

The microscopical examination shows the rock to be an eruptive of rather exceptional character and interest. It belongs to the general family of gabbros but with distinct traces and at times well marked

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diabasic or ophitic structure. The abundance, and at times, preponderance of hypersthene or enstatite shows its close affinity with the norite, while what is very exceptional, the occurrence of an abundance of quartz, as an original constituent. In fact many specimens could be secured which would contain as much quartz as an ordinary granite. In some instances, noticeably at the Copper Cliff mines, a large quantity of micro-pegmatite or granophyre is present, the felspathic constituent of this graphic intergrowth being plagioclase. Exposures show a massive medium to coarse-grained dark greenish or brownish rock which is almost black in colour on freshly broken surfaces. Scales of deep brown biotite are usually conspicuous, while the quartz is perhaps equally so in very characteristic sapphire blue or purplish grains, the colour which is so often seen in the phenocrysts of quartz, porphyries. The presence of this sapphire-blue quartz often serves to identify the rock even when it has undergone very advanced alteration, as is the case with most of the outcrops of greenstone in the township of Denison. The orthorhombic pyroxene, either hypersthene or enstatite, which is often idiomorphic was the first of the essential minerals to crystallize. The hypersthene is strongly pleochroic, rose red to nearly colourless; the enstatite on the other hand has little or no colour or pleochroism and very few inclusions. The rhombic pyroxene is very subject to decomposition so that in most cases perhaps, areas of this mineral are replaced by an aggregate of pale green brilliantly polarizing fibrous or scaly serpentine (bastite). This alteration is often accompanied by the separation of minute grains of magnetite. In most cases even the fresh individuals of hypersthene are bordered by a compact strongly pleochroic green hornblende which is doubtless an original constituent. This primary hornblende likewise forms borders on areas showing the complete bastitic alteration. In addition to this there is undoubted secondary hornblende resulting from the alteration, first of the bastite into actinolite and this in turn to the ordinary type of green hornblende. The plagioclase is usually in broadly twinned, stout lath-shaped or tabular crystals, whose frequent interlacing arrangement produces the characteristic rude ophitic structure. Separations by means of Thoulet's heavy solution as well as the extinction angles show that this plagioclase is labradorite. The presence of innumerable brown dust-like inclusions, presumably of ilmenite, gives to the felspar its prevailing dark colour. The monoclinic pyroxene occurs in large irregularly bounded grains. Biotite is an almost invariable constituent and is usually rather abundant and of undoubtedly primary origin. Apatite, magnetite, which is usually highly titaniferous, zircon, and occasionally grains of pyrite are present.

(b). Diorite.

Gabbro-diorite.

The least altered phase of the rocks with which the ore bodies are associated is what the late Prof. G. H. Williams calls a gabbro-diorite, that is a diorite which gives unmistakable evidences in the hornblende of its derivation from pyroxene originally present. Mineralogically, this rock as now represented by the thin sections examined, is composed essentially of plagioclase and hornblende. This rock contains, as a rule, only disseminations of the sulphides usually worked. It shows plagioclase in comparatively large amounts. This is evidently labradorite. It usually has undergone rather advanced saussuritization but many individuals are still sufficiently fresh to permit of their identification by means of the extinction angles. The resulting products of alteration are mainly sericite, epidote and zoisite.

Composition.

The hornblende shows the pale interiors with the deeper coloured borders so characteristic of uraltite. Biotite is almost invariably present and usually in large amount, often forming intricate parallel intergrowths with the hornblende. It frequently shows decomposition to chlorite. Ilmenite and highly titaniferous magnetite are the prevailing iron ores and these are present often in comparatively large amount. Most of the individuals are surrounded by opaque grayish leucoxene or the more normal sphene resulting from their alteration. The pyrrhotite and chalcopyrite occur as irregular skeleton or sponge-like masses chiefly associated with and imbedded in the coloured constituents. Quartz is almost invariably present, often in comparatively large amount, filling up the allotriomorphic interspaces left by the crystallization of the other constituents. It is not secondary but an integral part of the same magma out of which the other minerals have been formed. Apatite is often abundant, usually in small acicular prismatic forms. An increase in basicity is often accompanied by intense jointing and shearing action with frequent penetration and infiltration by vein quartz and calcite. Much of the original holocrystalline and granitoid structure is lost and replaced by a foliated texture marked by the parallel disposition of fibrous hornblende or actinolite and the pulling out or granulation of the plagioclase. The composition of the resulting amphibolite is essentially similar, but with prevailing less plagioclase and quartz, and more of the coloured constituents. The quartz is often in the small bluish or purplish grains so characteristic of the phenocrysts of the quartz porphyries of the Rainy lake and Yukon districts. Jointing structure is very prevalent, and this structure is so well and abundantly developed that it is almost impossible to secure good hand specimens without the sacrifice of a large amount of material. The schistose structure is also extensively developed and all gradations may frequently be observed in the same

Amphibolite.

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rock exposure, from the massive gabbro-diorite through diorite schist, hornblende schist or amphibolite to chlorite schist. The effect of pressure is much more pronounced and usual in the basic phases of the rock and an amphibolite is the result. An increase in these processes of shearing accompanied by vein action, favours the abundant development of chlorite at the expense of both the hornblende and biotite and the production of a highly chloritic actinolite schist.

The nickel-bearing rocks, include not only the norites, but some of the gabbro-diorites, which may be altered and differentiated forms of the norite and probably some of the more highly decomposed and schistose basic eruptives. In the vicinity of Copper Cliff and thence northward to the old Dominion Mine, it is possible to separate certain schistose basic eruptives, chiefly diorites and amphibolites, from the nickel-bearing eruptive or norite, the latter being of decidedly later age, but to the south-west, where the alteration is extreme, as in the township of Denison, it has been found impossible to do so in all cases. More detailed work might effect such a separation, for it is certain that all of the various basic rock types exist, but they are so intimately associated that it has been found impossible to effect a separation over the whole area. In addition, however, this greenstone portion, or nickel-bearing eruptive proper, passes northward into a more acid rock of granitic composition, with usually well marked gneissoid structure. The rock has usually been referred to as a micro pegmatite. There is no sharp line of demarcation between. The change though gradual is usually sharp enough to enable a boundary to be placed between the two types with tolerable accuracy. Outcrops of this rock are evenly banded or foliated with a distinct strike and dip, often show distinct or porphyritic structure, weather a pale reddish or grayish colour and are frequently intersected by irregular and often intricate vein-like masses of quartz of pegmatitic origin. On freshly exposed surfaces they are dark coloured with often reddish or yellowish phenocrysts. Orthoclase is apparently present in considerable amount but plagioclase (one near the acid end of the series, probably oligoclase or oligoclase, andesine) is more abundant. Biotite is the prevailing ferromagnesian mineral and much of it is often 'bleached' and altered to chlorite. In occasional instances the whole of it is thus altered giving to it the prevailing dark colour on fresh surfaces. The transition types between these and the greenstones show a varying proportion of hornblende, which in general diminishes in going northward, although certain bands of relatively greater basicity show an appreciable amount of this mineral, even at a considerable distance from the line of junction. One of the most noteworthy points in connection with these gneisses

Nickel bearing rock.

Micropegmatite.

Composition.

is the prevalence of micropegmatite or granophyre, and also the fact that plagioclase and quartz are the component minerals. This micropegmatite, together with the bisilicate material, chiefly biotite or chlorite, and sometimes hornblende and accessory epidote, ilmenite and sphene, form a groundmass in which comparatively large phenocrysts of feldspar, chiefly plagioclase but sometimes also orthoclase and microperthite, are embedded. The feldspar individuals often form nuclei around which the granophyre is developed.

Granite.

Younger granite.

It has been customary of late years to speak of certain areas of acid intrusives occurring in intimate association with the nickel-bearing eruptives as the 'younger granites.' There are two varieties of this granite evidently of the same age. One variety which makes up the large area is a very decided 'augen' granitite-gneiss. In places, it seems to pass gradually into the second variety, a finer or more even-grained granitite with ill-defined or no foliation. This coarse or 'augen' granitite-gneiss makes up a well marked batholith which forms a border along the southern side, of the main or southern nickel belt. Hand specimens usually show a very beautiful and typical coarse flesh red 'augen' granite-gneiss.

Composition.

Under the microscope, the thin section shows the rock to be made up chiefly of microcline, orthoclase, albite, oligoclase, biotite and quartz with epidote, sphene and apatite as accessory minerals and calcite, epidote, zoisite, sericite and chlorite as secondary products of decomposition. The orthoclase and microcline sometimes occur free; but for the most part are intergrown with the albite, forming both microcline, and orthoclase, microperthite. The quartz is the usual granitic variety, frequently showing intense strain shadows and sometimes granulated into a fine interlocking mosaic. The feldspars of the rock, although like the quartz often much cracked, broken and granulated, are comparatively fresh. Reddish-brown iron oxide has spread through the cracks, giving a cloudy or stained appearance to many of the grains. Much of the oligoclase has undergone considerable saussuritization, the resulting products being epidote, zoisite and sericite. It is usually stained a deep reddish-brown colour. The biotite is usually 'bleached,' and has often undergone more or less complete chloritization. The 'augen' are usually made up of a comparatively coarse-grained aggregate or microperthite or microcline and quartz. More rarely it is a single crystal of feldspar, never with well-defined crystal boundaries.

The finer-grained variety of granite is characteristic of two areas. The smaller one is situated immediately east of the Lady Violet mine and extends a little north of the Manitoulin and North Shore Railway on the boundary between McKim and Snider townships. The other larger area extends from the main line of the Canadian Pacific Railway, a little south-east of the Murray mine, north-east, nearly to the Little Stobie mine in the township of Blezard. A microscopical examination of the thin section shows an aggregate of quartz, orthoclase, plagioclase, biotite, hornblende, magnetite and zircon. The rock has evidently been subjected to great crushing. The structure is by no means uniform, but larger fragments are embedded in a finer-grained mosaic, which have resulted in great part from their peripheral granulation. The magnetite is highly titaniferous, as it is often surrounded by borders of leucoxene or the more normal sphene.

Two varieties
of granite.

Olivine Diabase.

The rock thus named, characteristic of what has been called the later dykes, is very uniform in mineralogical composition and structure. Hand specimens show a rock which is dark gray, greenish gray to almost black, with spheroidal rusty weathering which is very characteristic. In many instances, exposures exhibit a rude basaltic structure and are frequently porphyritic with phenocrysts of yellowish or greenish labradorite, often an inch or even more in diameter. The alteration of these phenocrysts produces the mineral 'Huronite,' so named by Thomson. These dykes possess well marked selvages of fine-grained, occasionally glassy material (tachylite) and present every gradation between basalt and diabase. The thin sections of the fairly coarse rock show a remarkably fresh olivine-diabase, made up chiefly of plagioclase, augite and olivine. The plagioclase is the principal constituent and is generally quite fresh and glassy, although occasionally somewhat turbid as a result of incipient decomposition. Being the earliest constituent to crystallize, it is in idiomorphic well-twinned, tabular or lath-shaped crystals, which have a marked ophitic arrangement. The extinction angles clearly indicate labradorite. The twinning is according to the albite law, but a combination of the albite and pericline law is very common. Occasional individuals exhibit twinning according to the rarer baveno law. The augite shows a very irregular or jagged outline with characteristic imperfect or interrupted cleavages. It is reddish-brown to violet in colour, and very distinctly pleochroic. The olivine occurs in more or less rounded pale yellow grains and sometimes fills in the spaces between the feldspar crystals. It is remarkably fresh but occasionally shows decomposition to a deep

Olivine
diabase dykes.

Composition.

green compact serpentine (antigorite?). Apatite is very abundant in the usual acicular prismatic forms, and the opaque constituent is probably ilmenite. Some of the thin sections are very instructive, especially as regards the order of crystallization of the various mineral constituents. Apatite was certainly the first to crystallize, as it occurs in sharp, well defined elongated prisms which are embedded in or pierce the other constituents. The labradorite has, in most cases at least, crystallized before the augite, but its relation to the olivine is not quite so distinct. In some cases the olivine has the rounded outline it usually assumes when its crystallization is not interfered with, but often it may be found occupying the triangular interspaces between the feldspar laths, or sharply moulded upon them. It appears, therefore, that the period of crystallization of the olivine, certainly overlapped that of the labradorite, although in general the olivine is distinctly later. Most of the ilmenite likewise is earlier than the plagioclase, but occasional individuals contain crystals of olivine and plagioclase, showing that some of the ilmenite formed after the olivine and plagioclase.

Age of dykes. These dykes of olivine diabase are distinctly later in age than the rest of the associated rock. They cut the greenstones and associated micropegmatite as well as the ore bodies themselves. They likewise cut the tuffs, breccias and quartzites, although one dyke was noticed which did not reach the summit of the quartzites, but was cooled against the upper beds. Their occurrence and the mineralogical composition of some of them in the neighbourhood of the Copper Cliff mine certainly very strongly suggests that they represent differentiated portions of the ordinary norite magma, representing the dying efforts of the very pronounced and long continued volcanism. For the most part they have a fairly constant direction, but present frequent broad curves and occasional faults. Two of the largest dykes met with, vary in width from 150 to 200 feet, and were traced with practically unbroken continuity from the north-west corner of McKim township south-east to Ramsay lake. There is no local enrichment whatever of the ore bodies in the vicinity of the dykes as has frequently been surmized. The influence occasioned by their passage in these ore bodies is extremely local and very insignificant. In the vicinity of the Copper Cliff and Murray mines and the area intervening, many of the dykes have been encountered and it has been found possible over this limited area to accurately determine and map their dimensions and direction, and although the prevailing direction is perhaps north-west and south-east, many of them occupy fissures with courses very widely divergent.

Width and length of dykes.

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The relations between the various eruptive rocks appear to be somewhat different from those supposed in previous reports. In the Sudbury sheet, it has been possible to separate and map out a series of greenstones and schists, which are the oldest eruptives met with. These are cut through and altered by what is commonly called the 'younger' granites and the breccia, formed by the invading granite; and the included greenstones covers considerable areas which are capable of being mapped. The younger granites themselves contain many fragments and even areas of these intruded greenstones. The norite, with which the nickel and copper-bearing sulphides are immediately associated is intrusive through and cooled against both the greenstone and breccia, and in many places a well-marked selvage or finer-grained portion of the norite is seen in the vicinity of the line of junction. The relation of the granite and the norite is, however, more complex, for although at one point the rock has cooled against the granite, as in the vicinity of No. 2 mine, Copper Cliff, at other places not far distant irregular tongues or apophyses of the granite apparently pierce the norite. It is probable, therefore that their periods of intrusion were so closely synchronous that they overlapped in their period of crystallization, and that the later secretions from the granite magma forced or ate their way into the norite.

Age relations
of eruptive
rocks.

The action to which the now famous nickel and copper ore bodies owe their present position and dimensions is much more complex than at first supposed, but the detailed examinations of many of the more important ore-bodies has served to emphasize very clearly some of the conditions attending and influencing their formation, and which were either minimized at first or overlooked altogether. These immense bodies, often of very pure sulphides, are no doubt, as generally supposed, genetically connected with the huge bathyliths of intrusive rocks with which they are always associated. It is also equally true that this sulphide material was introduced simultaneously and as integral portions of this same magma.* In obedience to Soret's principle governing the crystallization of complex solutions, these sulphides are segregated together for the most part in the immediate neighbourhood of the cooling surfaces which may be granite, breccia, greenstone or the several clastic rocks already described. Such a hypothesis however is manifestly inadequate to explain the presence of the larger ore bodies at least, and a more intimate acquaintance and study of their occurrence shows rather clearly that solution and redeposition has played a very much more important part in their formation than has hitherto been supposed. There can be little doubt of the abundant presence of such

Origin of
nickel and
copper
sulphides.

* The Nickel and Copper Deposits of Sudbury District, Bull. Geol. Soc. of Am., 1890, pp. 135-36.

heated solutions, containing the various mineralizing agents, and they evidently began their work of dissolving out, transportation and re-deposition, long before the magma had cooled, bearing their heavy burdens of sulphide material obtained from the magma to occupy the various cavities and fissures as fast as these were formed. It has long been remarked that everywhere in the vicinity of these ore-bodies, the inclosing rocks have undergone pronounced chemical and dynamical metamorphism. In many cases, all of the minerals are secondary and little or no trace has been left of the original structure. In addition, there is seldom lacking evidence of minor but appreciable and very frequent faulting and stretching, inducing the formation of the necessary spaces, while in many places there has been a replacement of considerable portions of the inclosing rocks by the sulphides. This extreme alteration of the wall rocks inclosing the ore bodies is the reason that the true nature and exact boundaries of the real parent plutonic remained so long unknown, so that the earlier petrographical descriptions referred to the rock as diorite, uralitic diorite, gabbro-diorite, diabase, uralitic-diabase and hornblende schists. The Baron Von Foullon and Prof. G. H. Williams were the first to call attention to the occurrence of the norite, but the true significance of their discovery was not appreciated until the appearance of Dr. T. L. Walker's 'Geological and Petrographical Studies of the Sudbury Nickel District,' which must be regarded as marking a very decided advance in our knowledge concerning the true nature and relations of these deposits and their associated rocks.

Three main
bands of
norite.

Northern
band.

There are three important bands of basic igneous rocks with which workable deposits of the various sulphides carrying nickel and copper occur. They may be distinct and separated, but genetically and mineralogically they are essentially identical. They likewise probably belong to the same geological period and are nearly, if not quite synchronous. The most northerly of these bands starts from the old Ross mine (W. R. 5), near the line between lots 5 and 6, on the concession line between III. and IV. of the township of Foy, and extends in an east-south-east direction into the township of Bowell, where on lot 6, in Con. II. it branches. One band runs south-west into the townships of Lumsden and Morgan, where its limits have not been definitely ascertained. The other band runs on to the east, cutting across the township of Wissner and crosses the Vermilion river, immediately north of Bronson lake. Trending still more to the north, it connects with the large basic area to the west of Lake Wahnapiatae. This mass extends for the most part in a southerly direction, and as far as at present ascertained, is lost in the extensive sand and gravel plains of the eastern part of Garson and the western of Falconbridge. It is thus

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so far uncertain whether this mass is continuous with the southern band of similar rock which, running through the third concession of Garson, is likewise covered up by the heavy mantle of drift. In my opinion this belt of basic igneous material which runs through Garson, extends in unbroken continuity beneath the drift, reappearing at the surface in the 4th and 5th concessions of the township of Falconbridge. It would however be extremely difficult to fully corroborate this view, as in many places the covering of sand and gravel is over 100 feet in thickness.

The second important band of basic igneous rocks, according to the present state of our knowledge, starts on lot 12 in Con. III of Trill, extends north and north-east through this township into Cascaden, and crossing under Windy lake, goes on uninterruptedly through the north-west corner of Dowling to lot 2 in the 4th concession of Levack. There is probably then a considerable break between this and the Ross mine on the northern nickel range, on the one hand, and the basic band which runs through part of Morgan, but both bands are almost identical in mineralogical composition and are certainly genetic equivalents. It is along the northern contact of this band and the granite gneiss to the north that the well known Levack deposits are situated.

The most important and famous band of norite, however, is the southern one, which starting in more or less small and isolated patches in the township of Drury, coalesces into one large band in the eastern part of this township. It then extends in a north-easterly direction as far as lot 3 in the 3rd concession of Garson, a distance of over thirty-two miles. The extremely basic portion would average nearly two miles in width throughout this length. The basic rocks extend over the greater part of the 3rd, 4th, 5th and 6th concessions of the township of Denison. About lot 2 it attains its maximum width of nearly four miles, but a short distance east is divided up into two belts by the intrusion of a mass of "augen" granite-gneiss. The northern, which is the more important of these two belts, runs in a direction of N.N.E. through the north-eastern part of the township of Denison and the south-eastern corner of the township of Fairbank. Thence it extends across the Vermilion river, covering the northern part of the 6th concession of Graham, and portions of cons. I, II and III, of the township of Creighton. From this place it runs across the central part of Snider, through the north-western corner of McKim, and the south-eastern part of Blezard, and with the exception of lots 1 and 2, extends with unbroken continuity across the third concession of Garson. Through Creighton and Graham this band is about two

Middle band
on Windy lake
eruptive.

Southern
band.

Distribution
and extent.

poles in width, while near the Blezard line it measures nearly one and a half miles across.

On lot 2, concession III of Snider, this norite sends an irregular tongue or dyke-like extension south-eastward and south, on which are situated the mines of the Canadian Copper Company at Copper Cliff. This band runs across the north-east end of Clara Belle lake. Crossing Lady Macdonald lake, it runs with practically unbroken continuity as far as No. 2 mine. The famous old Copper Cliff mine is a veritable chimney of ore, occurring in connection with an isolated stock of norite which comes in contact with felspathic quartzites and green schist. The openings in the vicinity of the Ontario Smelting Works belong to three separate masses of norite, which are surrounded by banded tuffs and quartzite. It is difficult to obtain hand specimens from the small area of norite in which the Evans mine is situated, sufficiently free from the sulphide material for purpose of examination.

The southern belt of basic igneous rocks runs across the Vermilion river, covering parts of concessions III, IV and V of Graham; thence on through Waters and Snider, it keeps to the south of the granite and north of a prominent ridge of quartzite, passing the Copper Cliff between mines No. 1 and 2. It is made up chiefly of diorite and amphibolite with possibly minor bodies of norite and a large amount of tufaceous material. Another large, though irregular body of altered norite, forms the rough country east of Sudbury and north of the Canadian Pacific Railway. It sends branches north-east across concession VI, Neelon, and south-west forms a series of hills to the north of Ramsay lake and Kelly lake.

Nickel mines. The Little Stobie mine, Dominion, the Davis property, Kirkwood and Cryderman mines, are situated on the borders of the main belt of norite with green schist. The Stobie and Frood mines occur in conjunction with comparatively small stocks or areas of norite, which are separated from one another. The Elsie mine occurs at the junction between norite on the one hand and green schist tuffs and hornblende porphyrite on the other. The Murray mine occurs at the junction between granite and greenstone breccias and green schists on the one hand, and the main band of norite on the other; while the old Cameron mine, further to the north-east, is found at the junction between the granite and norite. The North Star and Creighton mines occur at the junction between the granite and norite.

International nickel. Perhaps the most significant occurrence in regard to the progress of mining in the district, during the year, has been the formation of the

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International Nickel Company, under the laws of the state of New Jersey. This company is really formed by a consolidation of the Canadian Copper Company and the Orford Copper Company. The interests of the Anglo-American Iron Company and the Vermilion Mining Company have also been acquired by the new corporation, as well as the properties of the Nickel Corporation and the Societie Minière Caledonienne, in New Caledonia. During the past summer operations at Copper Cliff were carried on very slowly, but it is intended to resume work during the coming season on a much more extended scale than ever.

The Mond Nickel Company are actively engaged in the production of a high grade matte, which is shipped in barrels to the refinery at Mond Nickel Co. Clydach, Wales. It is stated authoritatively that these works have a capacity of about 1,000 tons of refined nickel per annum. The Lake Superior Power Company have also been mining at Elsie, and smelting the ore at the Gertrude mine. But beyond some prospecting and examination of various locations, all of the other properties are idle.

STATISTICS OF NICKEL AND COPPER PRODUCTION IN ONTARIO. Statistics.

Year.	Ore Raised.	Ore Smelted.	Nickel Content.	Copper Content.
	* Tons.	Tons.	Tons.	Tons.
1890	130,278	59,329	.....	.....
1891	85,790	71,480	.....	.....
1892	72,349	61,924	2,082	1,936
1893	64,043	63,944	1,653	1,431
1894	112,637	87,916	2,570½	2,748
1895	75,439	86,546	2,315½	2,365½
1896	109,097	73,505	1,948½	1,868
1897	93,155	96,094	1,969	2,750
1898	123,920	121,924	2,783½	4,186½
1899	203,118	171,230	2,872	2,834
1900	216,695	211,960	3,540	3,364
1901	326,945	270,380	4,441	4,197
1902	219,703	211,847	5,347	3,503

* 2,000 pounds.

ARTESIAN BORINGS, SURFACE DEPOSITS AND ANCIENT BEACHES IN
ONTARIO.*Dr. Robert Chalmers.*

Work during
winter of
1901-2.

The winter of 1901-2 was spent in the office, compiling the data collected in south-western Ontario during the previous summer, relating to petroleum, natural gas, salt wells and water supply, and in examining drillings, correlating logs of wells, etc. Information was furnished to drillers and others from time to time where work was going on. Proofs of my report on the surface geology of western New Brunswick were also revised and the report, with accompanying maps (No. 1 N.W. and No. 2 S.W.) was prepared for the Annual Report, vol. XII.

Character of
surface
deposits in
Glengarry
county, Ont.

Early in May, a few days were spent with Dr. R. W. Ells, of this survey, in Glengarry county, Ontario, examining the surface deposits there. The general surface of the country forms a plain about 350 feet in height * with a slight descent towards the St. Lawrence river. Moraines or boulder-clay ridges occur in some places, which trend approximately north-east and south-west, and numerous boulders from the Archæan rocks are scattered about over the area. Terraces, or water-levelled plains, usually consisting of coarse materials, occur associated with the boulder-clay ridges in certain localities, and appear to have been formed of the materials derived from the latter by their denudation during the Pleistocene submergence. These beds, though resembling boulder-clay, are usually stratified, and moreover, they contain marine shells of the following species,—*Saxicava rugosa*, *Macoma Balthica*, *Mya arenario*, etc., which prove their marine origin.

Nature of the
field opera-
tions of 1902.

On June 6, I began the regular work of the season, which was, for the most part, a continuation of that of 1901, embracing, besides the investigations respecting matters of economic importance, a detailed examination of the surface deposits. Some of the shore-lines of the ancient lakes were traced, wherever it was practicable to do so, and these are shown on the accompanying sketch-map. Though a large body of facts has been obtained, many of them new; full data from all parts of the interlake peninsula are not yet at hand, and further study of the region is necessary, especially in the north-western part, before a full and detailed report on it can be prepared.

* All the elevations in this report are referred to mean sea level, unless otherwise stated.

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At Brockville a few days were spent endeavouring once more to ascertain the nature of the contact between the known marine Pleistocene beds and the clays and sands to the westward, which appear, so far as studied, to be of lacustrine origin. Gray and yellow sands holding shells of *Saricava rugosa* and *Macoma Balthica* along with numerous calcareous concretions, were found on the banks of the St. Lawrence river half a mile above Brockville. Further west, near Lyn, gray, stratified clay was seen to underlie, and to be in contact with, these yellow beds. Similar deposits, occupying the same relative position, occur at the Grand Trunk railway bridge below Lyn. These two kinds of clay, the uppermost almost invariably containing concretions, were noted in a great number of places on the north side of Lake Ontario and Lake Erie.

PETROLEUM AND NATURAL GAS.

Considerable exploratory work in search of oil and gas has been carried on in the province of Ontario during 1902, and though most of it was unsuccessful, yet drillers and experts do not seem to have been discouraged. Oil and gas have been discovered in a few new localities, more particularly at Wheatley and in the townships of Romney and Raleigh, in the county of Kent. The first place where these were found was in the village of Wheatley, on the boundary line between Essex and Kent counties, at the depth of 1,110 feet. After the well was 'shot' a pressure of 440 pounds was reported. Gas from this well was piped into the dwellings, stores and factories in the village. Meantime, other wells were sunk in the vicinity and to the east, in Romney township, about two miles and a half from Wheatley, where the drill reached depths of 1,100 to 1,300 feet. Large areas of land were taken up there and north-eastward towards Charing Cross in the township of Raleigh and to Northwood in the township of Harwich on the supposition that an anticlinal axis extended in that direction. Two of the wells in Romney township were yielding some oil and gas at the time of my last visit in October and drilling operations were quite active. In November, oil was struck in Raleigh township near Charing Cross, about eight miles south of Chatham at a depth of 320 feet, or about 200 feet into the Corniferous limestone. Very exaggerated reports concerning this well were published, but from last accounts it was yielding oil with a pressure of about 140 pounds. The sinking of other wells was at once undertaken in the vicinity in concessions 12, 13 and 14 township of Raleigh, to depths ranging from 320 to 370 feet. Four of these are reported to be giving oil in greater or less quantities, but whether they are of permanent value or not remains to be seen. At

Explorations
for oil and
gas.

Wheatley.

Raleigh.

Northwood. Northwood, seven miles east of Chatham, near the Grand Trunk railway, oil has also been discovered, but in what quantities I have not ascertained. If an anticlinal axis extends from Wheatley to Northwood and Bothwell as maintained by some of the oil operators, its length must be about fifty miles in a north-east and south-west direction and the probabilities are in favour of profitable wells being found at some points along its course. The oil is, however, met with at two different horizons. At Bothwell, Northwood and Raleigh it occurs in the Corniferous limestone at depths between 300 and 400 feet, while at Romney and Wheatley it is found 1,100 to 1,300 feet deep in a hard vesicular limestone similar to that in which gas occurs in Essex county.

Collingwood. In regard to natural gas, it may be added that there has been a renewal of explorations at Collingwood, and the Trenton rocks there are now yielding it in limited quantities, sufficient, however, to heat and light some of the dwellings and drive the machinery in a few industrial establishments. The gas is found at depths varying from 100 to 300 feet, and at two or three horizons in each well, the surface deposits being from 30 to 40 feet thick. The first gas occurs at about a depth of 135 to 170 feet, or 100 to 149 feet in the rock, while the deepest gas rock is, as previously stated, at 300 feet or more below the surface. In Mr. Wm. Carmichael's well on Campbell street, in the town of Collingwood, the following beds were passed through:—(1.) Clay, 25 feet, hardpan, 8 feet; total for surface deposits, 33 feet. (2.) Trenton limestone, first gas at 135 feet; second at 165 feet; third gas at 237 feet, and the fourth and deepest at 288 feet; total depth of this well, 301 ft. 2 in. This may be taken as a typical example, showing the depth of the gas strata in all the wells sunk at Collingwood. The pressure in these wells is only from 20 to 30 pounds. A well was recently put down at the base of the Niagara escarpment, near Kirkville, passing through the Utica shales before reaching the Trenton, the latter being penetrated to a depth of 200 feet. A pocket of gas was encountered at this depth, and the pressure was so great as to throw out the water which was in the well and stop work; but it soon fell back to what it is in the wells in Collingwood. The greatest number of wells producing gas are found along a north-east and south-west belt, which passes through the town, though a few sunk to the south of this line have yielded gas. Three wells were put down on the high grounds west of the Niagara or Blue Mountain escarpment in 1901 to test the Trenton and other rocks there for gas, the heavy capping leading the drillers to suppose that the conditions were more favourable for an increased flow than in the valley to the north. One of these wells yielded a trace of gas, but the two others gave neither gas nor oil.

Niagara
escarpment
near Colling-
wood.

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In the older and larger gas fields, exploratory work and drilling have been continued in some localities, more especially in Essex county, but, so far as I could learn, without much success. The export of gas from the last-mentioned field to Detroit, U.S., was stopped in the autumn of 1901, but although the wells have been thus relieved, a steady though slow diminution in the flow of gas from the whole territory is apparent. In the Welland field a lessening of the flow is not so evident: nevertheless it is well known that the pressure there is also slowly diminishing.

Gas production in Essex and Welland field.

SALT.

The salt industry is still in a backward condition, though a new salt block has been erected at Sandwich, Essex county, and two new wells sunk near Sarnia, reaching a depth of 1,680 feet, and penetrating thick seams of rock salt. The works of the Windsor Salt Company have also been enlarged.

The salt industry.

The great extent and thickness of the salt beds of Ontario were referred to in the last Summary Report. During the past summer inquiries were made regarding the limits of the area occupied by them, and it was found that the opinion which prevails among the best informed of those engaged in the manufacture of salt is that the beds occupy a single basin and are practically continuous throughout. There are probably local areas in it without salt beds, these having formed islands in the sea or lake of the Onondago period upon which salt was not deposited. The salt basin extends from a point a few miles north of Kincardine, Bruce county, to Windsor or Sandwich, Essex county, a distance of about 170 miles, and its greatest width across the central part of Lambton county is about 40 miles. Whether it reaches the Lake Erie basin is doubtful, the wells drilled for gas near the lake not indicating salt. Neither is the western border known, but the salt basin probably extends below the waters of the southern part of Lake Huron and below St. Clair lake and St. Clair and Detroit rivers. The eastern and southern limits are irregular, but have been traced with some approach to accuracy from its presence or absence in the wells sunk in this part of Ontario. Six beds of rock salt, one above another, have been passed through by the drill in Bruce county, and also in the deep well at Petrolia, but it is from the upper seams only that the brines used in the manufacture of salt are taken. The depth of the rock-salt is somewhat variable in different parts of the field, and the beds have evidently the same dip as the inclosing strata. At Kincardine near the northern margin the uppermost salt seam is a little more than 300 feet below mean sea level: at Petrolia it is 615

Extent and thickness of the salt deposits of Ontario.

Six seams of salt.

Depth of salt beds. feet below the same datum; at Courtright 1,020 feet, and at Windsor 985 feet. From these figures it would appear that the deepest part of the salt basin is in the western part of the area. At Courtright, however, only one seam, 22 feet thick, was struck, and it is possible the uppermost salt seams are absent there.

PLEISTOCENE GEOLOGY, ANCIENT SHORE LINES, ETC.

Reference to classification of surface deposits.

A general classification of the surface deposits of the interlake peninsula of Ontario was given in the Summary Report for 1901, and two boulder-clays, separated by thick interglacial beds, were briefly described. The work of the past season has shown this classification to be substantially correct, and though in minor details the sections of the deposits may, in some localities, be slightly different in their constituent parts, it is now evident that there were, at least, two glacial periods in this region with an interglacial interval of considerable length between them. Evidences of these were noted as far east as Kingston, also at Trenton, Oshawa and along the Belleville and Midland railway. Further west the two boulder-clays were seen at Toronto, Woodstock and other places too numerous to mention. The stratified clays and sands associated with the boulder-clay deposits can only be very briefly referred to in this report.

Two boulder-clays.

Ancient Shore lines of the Great Lakes.

Ancient shore lines of the great lakes.

In south-western Ontario the evidences of ancient water-levels above the shores of the present lakes are shown in a number of places by shore lines cut into the clays, sands or gravels along sloping surfaces, and also by terraces formed of stratified deposits, and in some instances by beaches which have been thrown up by the waves. The strongest example of an ancient, abandoned water-level is probably the terrace abutting against a slope, but all three forms can be seen in numerous places in this region. In regard to the shore lines which were observed, I shall take the highest first, and the others in descending order. The elevations are all referred to mean sea level. Dr. J. W. Spencer speaks of shore lines or terraces 'up to altitudes of 1,700 feet,* but the highest of those observed by the writer did not reach that elevation. A terrace or bench extends for miles along the Niagara escarpment in Simcoe county at a height of about 1,400 feet (bar). In the central part of the peninsula, along the Owen Sound branch of the Canadian Pacific Railway, a number of local shore lines

Highest shore lines observed.

* A review of the history of the Great Lakes, American Geologist, vol. XIV, No. 5, p. 296.

THE HISTORY OF THE
CITY OF BOSTON

FROM THE FIRST SETTLEMENT TO THE PRESENT TIME



Geological Survey of Canada

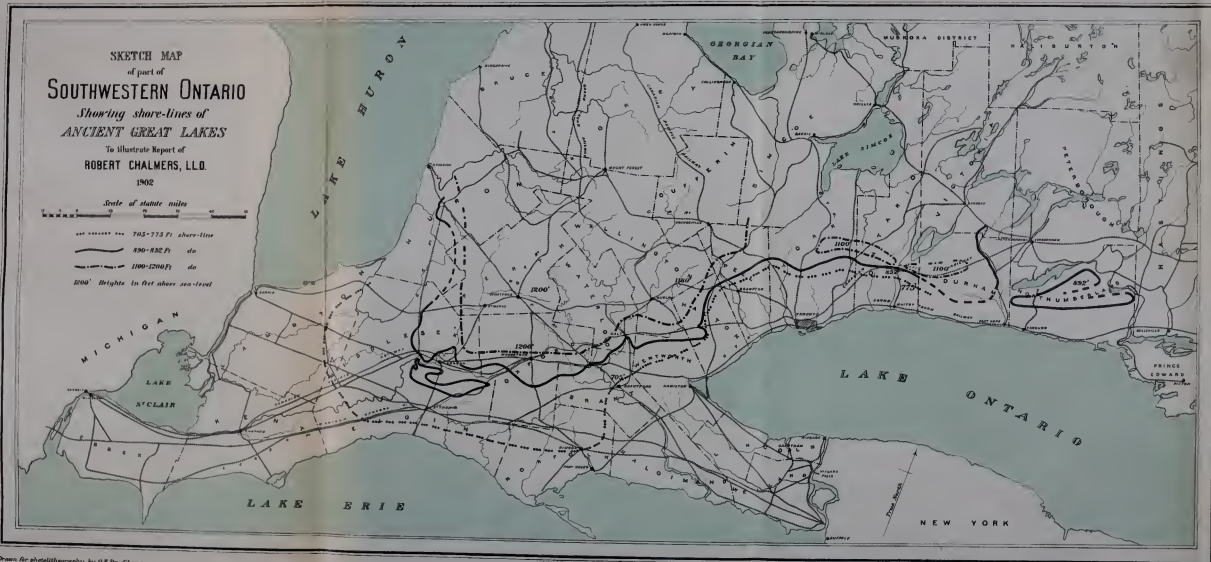
ROBERT BELL, Sc. D., (Canada) LL.D., MD., FRS, ACTING DIRECTOR
1903.

SKETCH MAP of part of SOUTHWESTERN ONTARIO Showing shore-lines of ANCIENT GREAT LAKES

To illustrate Report of
ROBERT CHALMERS, LL.D.
1902

Scale of statute miles
0 10 20 30 40 50

705-775 Ft. shore-line
890-932 Ft. do
1100-1200 Ft. do
1200' Heights (in feet above sea-level)



Drawn for photolithography by G.E. Prud'homme

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and terraces were observed,—one at Caledon station and Millville Junction, 1,356 feet in altitude extending westward some distance. Another lower terrace runs nearly parallel to the latter at a height of 1,260 feet. But the most extensive of these high-level terraces—one which may really be called a plateau, is upon the northern watershed of Lakes Ontario and Erie, extending from Durham county westward to Perth county. In Durham, Ontario and York counties it is comparatively narrow and the general direction is approximately east and west the average elevation being about 1,100 feet. A wide depression crosses it east of the Credit river.

West of this the plateau expands into a broad, roughly triangular area with the town of Stratford at about the centre, and is limited to the north-east by the higher grounds of Wellington and Grey counties. Upon its surface low hills and ridges rise above the general level, but for the most part it is flat and even and occupied by gravels, sands, silts and clay in a stratified condition, though boulder-clay is often seen levelled off at the same plane as the stratified beds. This plain increases in height from east to west, at Pontypool, in Durham county, the elevation being 1,100 feet, while at Stratford, about 140 miles to the west, it is 1,200 feet.

Descending from this high-level terrace, we reach a shore line which, excepting the Iroquois beach, is the best defined of those met with on the north side of the lower Great Lakes. Its average elevation above mean sea-level is 890-892 feet, according to the railway levels, on which all the measurements were based, and it seems to be practically horizontal throughout. This shore line was traced from Trent river, in Northumberland county westward to Hyde Park in Middlesex county, a distance of fully 200 miles. From Hyde Park it trends northward, and was followed to Clinton, though not as closely as in its east-and-west extension. East of the Trent river, or rather east of the Belleville and Midland railway, (Grand Trunk,) it could not be definitely traced. In its general features it exhibits cut terraces, wide, water-levelled plains, and in some instances, wave-built beaches. It is intersected by a transverse valley in its eastern prolongation through which the Port Hope and Peterborough railway runs, but west of that it is continuous throughout, except where the Thames river crosses it. It was not traced farther north than Clinton or Holmesville, Huron county.

Shore lines,
how far
traced.

Below this there are traces of another shore-line higher than the Iroquois. Its elevation was measured at several points, for example, at Myrtle station, Grand Trunk railway, where it is about 775 feet; at a point south of Richmond Hill, York county; south of Harrisburg

Gradients of
the shore
lines.

Junction, Grand Trunk railway; north of Brantford, and at Kingscourt Junction, Komoka and Sarnia branch, G. T. R. The elevations vary from 775 feet, at Myrtle, as stated, to 705 feet in its westward extension; but this shore line has not been traced in sufficient detail yet to enable me to generalize in regard to it. The gradient seems, however, to be greater in the eastern than in the flat country in the western part of the peninsula. The Iroquois beach below this has a still greater slope westward, that is, between the Trent river and Dundas, according to Spencer and Collman.

Differential movements of the land indicated.

The highest of the water-planes and shore lines referred to are, no doubt, the oldest, but even these must have been produced since the last glacial period, as they bear no traces of ice-action. When the 775-705 feet shore line was being formed, and still later, the Iroquois, the 892 feet one, as well as the 1,100-1,200 feet plateau, must have had an eastward or north-eastward slope. The 892 feet shore line however, strange as it may seem, has just about returned to its original horizontal position. The changes of level indicated by the several altitudes and gradients of all these shore lines, viewed in relation to each other, point to differential or east-and-west see-saw movements, which were much more complex than hitherto supposed. Further study of the phenomena is very desirable.

Clays, Sands, Gravels, etc.

Stratified deposits, clay, sand, etc.

Considerable information has been collected relating to the character and distribution of the clays, sands, silts, marls, etc. Besides the boulder-clays referred to on a previous page, the stratified clays and sands form the largest part of the surface deposits, occurring everywhere throughout the province, and the industries depending upon these materials are rapidly increasing in value and importance. The manufacture of bricks and tiles is now carried on near most of the cities and towns, and no difficulty seems to be experienced in getting clay and sand suitable for this purpose. At most of the brickyards the surface clay and sand only are used, which burn into red bricks. But in the south-western part of the province large quantities of white or cream-coloured bricks are made from the Erie clay, which underlies the clay above mentioned. The localities where the different kinds of clays and sands occur are so numerous that it is impossible to mention them in this report. But they have been described in considerable detail by Dr. Robert Bell in the *Geology of Canada*, 1863, pp. 896-915. Sands and silts often form ridges and mounds upon the higher terraces between Manvers and Whitechurch townships. The detailed information collected during the past two seasons concerning the surface deposits

Uses to which they are now being put.

Bricks and tiles.

Description by Dr. Bell in *Geology of Canada*, 1863.

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must be passed over in this summary, and await a more detailed report.

PEAT.

A good deal of interest is taken at the present time in the manufacture of fuel from the peat bogs of Ontario. Experiments in drying and pressing the crude moss have been going on for a number of years and attempts made to produce a marketable article of fuel which would be cheap, of small bulk, and easily handled. Recently it appears that at three or four of the peat bogs at least, the efforts of those interested have been successful, while at others the methods devised are being tested and will probably be adopted. Briefly described, these methods are:—First, the draining of the bog; then air—and sun-drying the crude moss in the field until the quantity of moisture in it is reduced to 50 or 60 per cent or less; afterwards collecting and bringing it in to the peat works. These operations constitute what is called ‘harvesting’ the peat moss. When brought to the works it is either piled in heaps or stacks, or delivered into a machine called a ‘breaker,’ which breaks or cuts it into small particles to facilitate drying, after which it is carried to the drier by an endless belt and buckets. Several driers have been invented and tested, but the one known as Dobson’s seems, so far, to have proved most serviceable in the drier peat mosses of Ontario. It is a hollow steel cylinder, 30 feet long and 3 feet in diameter, which is placed inside a brick furnace and mounted on an axle at a slight inclination from a horizontal position. Heat is applied under the higher end, the peat from the breaker being delivered into this end automatically from above. The drier is made to revolve slowly, and ‘angle irons’ inside, arranged at proper distances apart, lift and break up the peat still more as it is moved about inside the drier, until, by gravitation, it reaches the lower end of the cylinder. From the drier it passes, as a fine dust, into receptacles which convey it to the press. It is then dropped into the dies, of which there are eight on a revolving block, and is there subjected to a pressure in each of not less than 50 tons weight. By another movement of the press the block of pressed peat, or briquette, is forced out below and caught up by the buckets of an endless belt and carried to a storehouse or bin. At the Beaverton works, where operations seem to be well systematized, the whole series of processes, from the cutting of the peat in the field to its storage in the bin, costs only about 90 cents a ton. From twelve to fifteen tons of pressed peat are produced daily with only one drier. These works have been in operation for two years, and the peat briquettes find a ready sale at Beaverton and the nearest towns.

Methods of
converting it
into fuel, or
briquettes.

Description
of drying
process.

Presses.

Beaverton
peat works.

A peat bog situated about eight miles north of Stratford, contains 1,200 or 1,300 acres, and is known as the Stratford bog, or Huckleberry marsh. Here the manufacture of peat fuel has also been undertaken. The whole process of harvesting, drying and pressing the peat moss into briquettes is precisely similar to that of the Beaverton works, and so far as I could learn, is also proving a success. The plant is the same as that of the Beaverton Peat Fuel Company, and indeed, has been constructed from Mr. Alex. Dobson's patent.

Stratford bog. The Welland peat bog is situated in Welland county, and contains 4,000 acres or more. It is now six or seven years since the company operating here (The Welland Peat Company) began the exploitation of this bog, and experiments in drying and pressing the moss, have meantime, passed through a number of stages. The preparation of moss litter was first tried, but eventually, this gave way to the manufacture of peat fuel. The experimental stage, seems now, however, to have been passed, and plant adapted to the special requirements of the peat moss has lately been installed. The character and condition of the peat are somewhat different from those of the Beaverton and Stratford bogs. The Welland moss is wetter and different methods have had to be employed in harvesting and depriving it of the moisture it contains. It has been shown by experiments made at other peat works, that the maximum amount of moisture left in peat after passing through the press, must not be more than 10 to 12 per cent, in order that the briquettes may not be brittle or break up readily. But it was found that passing the peat of the Welland bog through a 30-foot drier, once, did not reduce the quantity of moisture to this point. Hence, the company had to get a double or triple drying-cylinder, equal to about 90 feet of a straight drier, to effect that end. The difficulties encountered in the drying process having thus been overcome, three new driers were about being put in at the time of my visit, making four in all, with a capacity for producing 100 tons of pressed peat a day.

Welland bog.

Drying and compressing plant at Welland.

The peat of this bog has to be screened before it is put into the breaker as it contains roots of trees and shrubs. These roots are, however, used for fuel under the driers, instead of crude air-dried peat, as at Beaverton and Stratford.

Victoria Road peat work. At Victoria Road, on the Trent Valley canal, about two miles north of Kirkfield, there is a peat bog of 110 acres, and here an attempt was made by the Trent Valley Peat Fuel Company to manufacture fuel on a large scale. Very extensive works were erected and operations carried on for two years or more, but owing to the difficulties met with in the drying process also, they were closed in 1902. The peat moss

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is under water, and had, therefore, to be dredged, and the efforts which were made to remove a portion of the water it contained by pressure before conveying it to the driers, were not successful, and besides, were, I was informed, too expensive.

Another peat bog to the north of this, on higher ground, is much better situated as regards drainage and facilities for drying by the air or sun, and it is reported that the company above mentioned may commence operations there.

The Rondeau peat bog is on the west side of Rondeau Harbour, Rondeau bog, Kent county. The surface of the moss is nearly on a level with that of Lake Erie, and at the time of my visit the pit from which the peat was being taken was flooded and operations had temporarily ceased.

A large peat bog lies three miles north of Brockville. Here the manu- Brockville peat. facture of peat fuel was undertaken, but the company was met by the usual difficulties in the drying and compressing processes, and had to close operations. The property, I am informed, has since been acquired by the Peat Industries, Limited, of Brantford, and their improved plant was to be installed at an early date and operations resumed. The bog is rather a wet one, the artificial channel which drains it apparently not having been cut deep enough.

Preparations for manufacturing peat fuel have also been commenced Newington peat works. at Perth, Picton, Galt and other places, and the Dominion Peat Company of Brantford is about to begin the manufacture of fuel and coke from the moss of a large bog at Newington, Stormont county.

Other peat bogs were noted in different parts of Ontario, for Bogs not yet utilized. example at Redmonds Pond, west of London, at Jacks lake, south of the mouth of Nottawasaga river, also in the basin of Balsam lake, and at the Mer Bleue, east of Ottawa. No attempts have yet been made to work these for fuel or moss litter.

The question is often asked, can peat fuel be prepared by the Present methods of drying and pressing peat not capable of producing fuel in large quantities. present methods of drying and pressing it in sufficient quantities to enable the manufacturers to place it in the fuel markets of the country for general sale along with coal and wood. Hitherto this has not been done, and the limit of production seems to be reached when the nearest towns and villages are supplied. The great difficulties in regard to preparing it in large quantities lie in the preliminary air-drying or so-called 'harvesting' processes. In winter, as is well known, the bogs are frozen solid, so that it is impossible to obtain the crude peat then to carry on operations. Under these conditions, how can a

Only about 100 days in the year in which peat can be sun-dried.

Large drying areas necessary.

Costs of air drying process.

Peat briquettes.

Dead bogs.

manufacturer get a supply sufficient to keep the driers and press running all the year round? The present method is to store up as much of the air—and sun-dried peat in the summer months as possible. But in wet summers this quantity must be limited, indeed, the managers of peat works inform me that, as a rule, they can only get about 100 days in the year to dry the crude peat in the field. It is evident therefore, that if, on account of a wet summer, or other causes a sufficient quantity of the raw material is not collected, the industry will be seriously hampered. However, matters are not so bad as may seem at first glance. Considerable quantities of the raw peat are usually stored. Moreover, it has been proved by experiment that it is not necessary to store air-dried peat under cover for winter use, if the moisture in it is reduced to 50 per cent or less. Stacking or piling it up in the open air is just as effective in keeping it dry, that is to say, it will remain in the same condition in regard to the contained moisture as when collected. Peat well dried by the air and sun does not usually contain more than from 20 to 40 per cent of moisture. Large heaps of air-dried peat were shown me at some of the bogs which had been exposed to the weather for a year or more. Openings made in these showed this peat to be as dry as when collected except 12 to 15 inches on the outside, which was the depth to which the rain had penetrated. From these facts it would seem that in order to have a sufficient supply of crude moss on hand to keep the driers and stamps of any of the peat works in operation the whole year round, it is necessary, first, to have a large drying area, and second, to employ a considerable number of men during the dry weather of summer for the outdoor operations. The air-drying process is the cheapest, and probably the most expeditious in the preliminary stage. At the Beaverton works the total cost up to the delivery of the raw peat at the breaker is reported to be only about 40 cents to the ton of pressed peat.

Peat briquettes are impervious to the moisture of the atmosphere, if kept under cover, but if exposed to rain or snow they absorb water and swell up and burst. They have a calorific power of about three-fourths that of ordinary coal, while that of crude peat is about half that of coal, the accurate proportion being as 1 to 1.8.

The peat bogs or moors of Ontario consist, to a large extent, of dead peat, those parts which contain the living moss being limited and scattered. The growth and accumulation of peat here has, therefore, practically ended. The dead condition of these turbaries is due to several causes, some of which are not easy to explain, but the principal causes seem to be (1) the clearing away of the forests and the partial

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dessication of the country surrounding the bogs ; (2) artificial draining and attempts at cultivation ; (3) fires overrunning them in dry seasons, &c. In consequence of these changes the quality of peat is more or less impaired. Dust and other mineral matters are more likely to get into it, especially near the border, when the peat is dead. Moreover, the lower part of the bog is then more liable to decompose, the fibre of the peat to become destroyed and pass into humus. Peat fuel manufactured from material of this kind, therefore, is not likely to be as clean and free from mineral matter as that obtained from green living bogs. Ordinary clean peat should not contain more than about five per cent of ash. The upper part of the Ontario bogs, that is the part from two to four or five feet below the surface, probably contains the best peat for fuel, and the centre of the bog will have cleaner moss than that at or near the margin.

In closing I desire to thank Mr. Horace P. Chamberlain, general manager of the Imperial Oil Company, Sarnia, for a number of logs of wells sunk in Ontario, and Mr. Charles O. Stillman, general superintendent of the Sarnia Oil Refinery, for information courteously given. To Messrs. James Kerr, Petrolia, A. F. Hunter, M.A., Barrie, Wilson Irwin, Toronto, Alex. Dobson, Beaverton and William Carmichael, Collingwood, I am indebted for assistance and various acts of kindness.

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THE ALGONQUIN SHORE-LINE IN SIMCOE COUNTY, ONTARIO.

Mr. A. F. Hunter.

Simcoe county covers 1,627 square miles, has a maximum length of 58 miles, and a greatest breadth of 52 miles. In this limited area, the ancient Algonquin shoreline has a lineal extent of some 450 miles. This great length is owing to its numerous windings around peninsulas, bays, islands and every other form of shoreline.

Area of Simcoe county.

It follows from this circumstance that more than half of the surface deposits of the county are the direct products of the Algonquin water, notwithstanding the fact that many other shore-lines are found here. No other physical agent was so potent in producing the present economic conditions of the county. For, in addition to the phenomena connected with existing parts of the ancient beach, there are very many wide tracts of boulders lying far out from the shore-line which were shoals during the existence of the Algonquin lake or sea, and they owe their denudation to this great water-body. Hence the Algonquin lake or sea has been the dominant factor in making the county's soils and deter-

Origin of surface deposits.

mining its watercourses, and even in modifying the distribution of its flora and fauna.

Area of
former land.

The contracted area of the dry land in what is now the county of Simcoe in Algonquin times was about 680 square miles, consisting chiefly of islands and crab-like peninsular forms. The remaining 947 square miles lay under water with the meandering shore-line of 450 miles. It is a singular fact that the 680 square miles thus unaffected is nearly all good soil, while the 947 square miles consist largely of sands and gravels, deposited on the bed of the lake. In most places the Algonquin deposits completely obliterate any glacial characteristics that might once have existed, but above the shore-line there are a few features that may be attributed by some geologists to glacial agency.

Former
islands.

In the southern and western parts of the county, the Algonquin sea lay against the mainland. A group of large islands extended nearly from Lake Simcoe north-westward to Georgian bay. The largest island, which covered about 120 square miles, and included the chief part of the township of Oro, lay nearest Lake Simcoe; and in a general way the others diminished in size toward Georgian bay. The longer axis of this island group seems to follow an old escarpment which was closely parallel with that of the Blue mountains at the west side of the county, the islands being the portions which have escaped denudation. Some exposures of rocks occur along the Blue mountain escarpment, but none in the row of islands, the latter being heavily covered with drift. The general direction of the broken face of the old escarpment, which I shall call the north-easterly escarpment, as shown by the Algonquin shore-line along the islands, is north-west by west. That of the shore-line along the Blue mountain escarpment is north-west by north. Thus they are closely parallel with each other, but not exactly so.

The Algonquin lies about midway in elevation in a series of shore-lines, all of which are more or less definitely marked in this county. First, I will pass upward from this shore-line, taking it as the datum in my descriptions.

Other old
beaches.

One of the most prominent features of the Algonquin beach is an upper strand, about 40 feet above the main cutting. This is observable for the most part where the land slopes very gradually; at places where the slope of the surface is steep near the shore line, its faint traces have been entirely obliterated by the strong action of the waters during the subsidence which followed. This appears to have been the starting level of the true Algonquin shore-line. Wherever the name Algonquin is used in this report, it refers to the Lower Algonquin beach, which is, in every respect, the more important.

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Besides the markings at 40 feet above, there are others at 70 feet and again at 110 feet also above the principal shore line. All three become well marked shore-lines along the north-easterly (broken) escarpment, but along the face of the Blue mountain, I am unable to recall any but the markings at 40 feet, which I regard as a part of the Algonquin itself, or the earliest stage of it. The other two are probably somewhat local, appearing as they do along the more exposed places. All three are connected with phenomena due to the action of shore ice.

The next prominent shore-line above the Algonquin occurs at about 160 feet. Where it is well preserved it appears double, the two strands being separated by a space of about 15 feet. Its double character suggests possible tidal action. This 160 feet shore line has an oceanic aspect. It is not always distinctly defined, but is accompanied by evidence of much laving, and a broad, though sometimes eroded plain beneath it. Being much older than the Algonquin beach, it is not nearly so well preserved. One finds the Algonquin marked in ten places for one in which he finds the 160 feet shore line, but this difference may not be entirely due to the difference in age. The latter is easily traceable, however, by its broad water-levelled plain.

There is abundant evidence in the zone between the Algonquin and the 160 feet shore-line of a period of thick shore ice, such as might be produced by a sub-arctic climate like that of the present Great Bear lake, but there is no evidence within my range of observations of any land ice or other glacial features. The evidence of shore ice is furnished by the multitudes of ice-formed reefs to be seen in sheltered bays within the zone. The uppermost layer in those cliff exposures is usually a mixture of gravel, clay and pebbles, having a cemented character in most places. My observations led me to regard this mixture as debris from the deposits of shores immediately above the Algonquin, and I further consider the thick deposits of sand always underlying this material as the products of the strong shore-line at 160 feet. In one instance, viz., on the north half of lot 16, concession XII., Innisfil, I observed this thin cemented covering of boulder clay to dip with the slope of the hill in the side of which the exposure occurs.

The next shore-line is one about 230 feet above the Algonquin. This has a terrace even broader than that of the 160 feet shore-line, but its actual water-line is more indistinct. Indeed, the shore-lines become more extended and with a more oceanic aspect as one ascends the series. There are shore-lines at about 310 and about 410 feet above the Algonquin, in addition to those above referred to. The

altitudes of these are deduced from my observations on the 'Insular Tract' in North Simcoe. Similar high shore-lines occur up the sides of the Blue Mountain escarpment in the western part of the county, and they are probably at corresponding altitudes, but I have not attempted to correlate the two series, or rather the two parts of the same series, higher than the 160 feet shore-line, which is a conspicuous feature along both escarpments of the county.

Shore-lines
below the
Algonquin.

Returning to the Algonquin and passing downward from it, the first shore-line is found at about 60 feet below. The best markings of this shore are found along the north-easterly escarpment, but are occasionally met with in other parts of the county, though, as a rule, only faintly. This shore-line, or a counterpart of it within an inner basin, occurs a short distance south and west of Angus. The entire valley of the Nottawasaga river above this is devoid of shore-lines until the Algonquin is reached, and between the two there is a continuous plain. In connection with this shore-line, which I shall designate by the letter A for the sake of brevity, some beds resembling boulder-clay occur in protected places. Instances of these will be found mentioned in subsequent parts of this report.

The next shore-line beneath A is some 50 feet lower than the last mentioned, and is considerably stronger than A. I will designate it as B. The succeeding ones, C and D, are also strong. In fact, it might almost be said that this infra-Algonquin series, which has been called the Great Nipissing series by F. B. Taylor, increases in strength as we go downward from the Algonquin. The later members of the series are marked only against the north-easterly escarpment. Westward, near Collingwood, none but the first three are to be seen, the later ones having coalesced with the existing shore of Georgian bay.

I cannot assert positively how many shore-lines may exist in this infra-Algonquin series. There are at least five, and as you travel north-eastward, where the uplift raises the whole series higher above the present level of Georgian bay, new ones seem to make their appearance. The series ends in uncertainty.

Fresh-water
shells.

Fresh-water shells begin to make their appearance with the shore-line B. They increase in abundance until we reach shore-line D, in connection with which great deposits of shell-marl occur in the flats of the Nottawasaga river toward its mouth. The great abundance of fresh-water shells at this stage of the subsidence suggests a much warmer climate than even our present meteorological conditions. Dr. Robert Bell has found similar evidence of a milder interval than the

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present day in deposits on the north side of Lake Superior. (The Geological History of Lake Superior, Trans. Can. Inst., vol. VI., p. 54).

Along the Blue mountain escarpment, especially toward the head of the Georgian bay of Algonquin times, the shore-line has many bays and deep indentations; but along the north-easterly escarpment, especially at the northernmost islands, the outlines have a smooth rounded character which is quite noticeable when the contour of the shore-line is seen on a map. This difference, which is accompanied by a corresponding increase in the strength of the cuttings at the outermost places, seems to be entirely due to the greater exposure at the north to a more active sea. The difference is not traceable to uplift or deformation of the shore-line while the water body was cutting it, but almost, if not quite all, to the uplift in subsequent times. The markings at 40 feet above the Algonquin and the higher members of the infra-Algonquin series are quite parallel with the Algonquin itself, and show practically the same degree of uplift. They also show greater intensity along the north-easterly escarpment, and hence the whole phenomenon may be regarded as due to greater exposure to the wave action. I have identified the Algonquin, east of Lake Simcoe, at Bolsover and other places in that neighbourhood, and it has an appearance resembling what it possesses in the more central parts of South Simcoe; hence I infer that the portions of it seen by me in Victoria county were amongst islands, where the action of the waves was more subdued.

In well developed examples of the Algonquin in Simcoe county, the main cutting is seen to be the result of the concentrated efforts of some five periods of intensity. In other words, the wave action was intermittent, as shown by the wave-built reefs of water-worn materials. Two such examples were noted in our survey of the shore-line in the township of Oro.

The uplift or deformation of the Algonquin toward the north-east is quite considerable in this region. At Barrie the beach is 780 feet above the sea; at Silver creek, due north of Orillia town, distant 24 miles from Barrie in a straight line it is 875 feet. Along this line, therefore, the uplift attains 4 feet in a mile. Silver Creek is on the edge of the north-easterly escarpment. At Lisle, on the edge of the Blue mountain escarpment, its altitude is 750 feet. Lisle is distant from Barrie, 15 miles in a straight westerly course. Hence, along this line, which crosses the valley of the Nottawasaga river, the uplift is 2 feet to the mile.

Uplift to the north-east.

The old water-line of the Algonquin has a larger number of springs issuing along it than any other shore-line above or below it. This

feature led to the selection of the Algonquin cliff tops for the sites of many Huron Indian villages in the earlier days. Elsewhere I have dwelt more at length upon this circumstance, and upon the use of the ridges (morainic and other kinds) by the Indians for their forest trails.

Shell-marl. Shell-marl deposits are conspicuously absent from the list of materials in the beds below the Algonquin shore-line. But, as above mentioned, thick deposits of this material occur in the deposits of some later shore-lines in this county. The action of a beach in making a deposit of shell-marl is to be seen on the present shore of Nottawasaga bay. The waves break up the shells into small fragments, but some escape whole and are thus found in the marl afterward.

Fossils. Fossil fishes occur in Algonquin clays in the townships of Tay and Essa, and these cases will be found mentioned more particularly a few pages further on. They, however, did not come directly under my own observation, but I believe these instances constitute evidence that the Algonquin clay-beds are fossil-bearing. The sand deposits formed in shallower water than the clay can hardly be expected to retain any traces of fossils. Along the shore-line itself the intensity of the water action would be so great as to destroy shells and other dead organisms, if there had been any, and the coarse materials would not preserve them even if they had escaped destruction.

In artesian wells in this county, water does not rise above the Algonquin level; and there are no wells of this kind above the shore-line, so far as my experience goes. The case is different in other counties where wider bodies of the land of Algonquin times are to be found; but the land tracts of Simcoe county were too small to give any great force of water above this line.

NOTEWORTHY FEATURES ALONG THE ALGONQUIN SHORE-LINE.

Noteworthy features. The Algonquin shore-line enters Simcoe county on lot 42, concession XII., Nottawasaga township and crosses the adjoining lots northward. Extensive boulder pavements are to be seen here, the finer materials from which the boulders have been separated and left, being found a few miles to the south-east. In general, the foot of the Blue Mountain escarpment corresponds with the Algonquin shore-line, more or less closely, and in some respects it is more conspicuous than any of the other shore-lines, above or below it.

Where it crosses Hurontario street or the eighth line of Nottawasaga, there are to be seen several ridges on lots 32 and 31. The shore-line

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itself occurs southward in lot 31 near lot 30 on this line. At the crossing of the sixth line east, ridges and tracts of gravel are quite extensive, and the Batteau creek is very pebbly on lot 30 and for some distance above and below. The gravel has evidently been carried from the boulder tracts, six or seven miles to the north-west, as mentioned above. On this same (sixth) line southward from the crossing, for about two miles, including lot 27 and others south of it, the soil presents a much washed and flooded appearance, although there is good loamy farming land everywhere above an elevation of about 40 feet over the shore-line itself. The evidence furnished by this instructive place (on the 6th) is that the Algonquin lake or sea began its work about 40 feet above the main or final shore-line, and kept gradually settling down, leaving a zone of land for 40 feet above with a washed appearance. This feature is also seen at many other places, including an example on the ninth line of Vespra, but in the latter instance, there may have been some tumbling down of the final cutting, the 40 feet marking having been eroded away.

Washed soil.

On the No. 24 side-road in concession IV., the shore-line is represented by a high gravel ridge, which is traversed by a stream. That part of the ridge lying north of the stream is boldly prominent and resembles a ridge of apparently similar formation in lot 9, concession XI., township of Tiny. Further lakeward than the gravel, viz., around the town of Stayner, there are thick deposits of sand whose origin has obviously been in the Algonquin water.

Passing now into Sunnidale, a prominent projection known locally as 'Cornhill,' protrudes fully two miles into the Algonquin lake-bed and far beyond the general line of the Blue Mountain escarpment. The land upon Cornhill is good, hence its name; but that on the flat ground around it is poor, having been washed by the ancient lake. The lake at the Algonquin level came very nearly making an island of Cornhill; a shore-line 70 feet above it did so. A strong and well preserved cutting of the Algonquin occurs along the outer or lakeward edge of Cornhill; this cutting having for its most easterly reach the boundary between lots 4 and 5, concession V. Up to this point in our itinerary, this is the best developed cutting we have encountered, and it is the strongest example I have observed anywhere from the place of beginning, although it cannot be compared for strength with some cuttings along the insular 'escarpment' in the north-easterly part of the county, made by the Algonquin waters.

Cornhill,

The crests or ridges on Cornhill and in its immediate neighbourhood at this part of the escarpment, whether they are the results of glacial

phenomena or not, have a north-west and south-east direction, and in this respect they are exceptional or differ from other ridges almost everywhere throughout the county. As they now appear on Cornhill their course suggests that they have been cut away to this shape. Through Nottawasaga, township up to this point the ridges have usually a north-east direction, so far as any order can be made out; and four miles south of Cornhill, at Banda, they again run north-east.

The cutting at the apex of Cornhill is the starting point of the extensive Pine plains, which will be referred to further on. On the cross road between lots 6 and 7, concession IV., Sunnidale, a little way north of the road to New Lowell, there are surface deposits of the highly coloured red sand with continuous deposits of whitish marl or other chalky substance in a powdered condition. This is a short half mile from the cutting and about 60 feet below the shore-line, the usual depth at which such deposits are found.

Along the south side of the Cornhill projection, a deep recess runs into Nottawasaga, entering that township in lot 9, concession I. This recess contains a large Algonquin island of some 2,000 acres in extent. On the side of this island facing the south-west is a very strong cutting which extends four miles from near Glencairn to a point south-west of Cashtown, where the island ends. Abundant gravel beds lie beneath the surface.

Avening and
Glencairn.

The district around Avening and Glencairn is several feet lower than the Algonquin beach and the Pine plains in front of it, and may have contained a small inland lake for some time after the period of the Algonquin: this tract is now drained by Mad river. Good fertile soil is found in the supposed former lake bed. Mad river has cut a canyon through the Pine plains. In lot 33, concessions II. and III. Tosorontio, the canyon contains terraces, showing an intermittent character in its excavation. Where the branch of the Mad river that comes out of Mulmur, crosses the 7th line of the township in lot 28, there is a distinct terrace 40 feet above the Algonquin, in the canyon or valley.

On the south-west side of this recess in the escarpment, i.e. S.W. of Avening, a tract of very high ground juts to the east, and is visible, standing out by itself, for a long way. Otherwise described, the Avening recess is bounded on the S.W. by projecting high ground, immediately south of which is another recess in which Randwick and other places in Mulmur, are situated. But the Randwick recess does not contain any Algonquin bay, although the shore-line about 160 feet above it, extends far into this recess, and makes some islands lying within it.

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South of the Randwick recess, a projection known locally as the Oak Ridges. 'Oak Ridges' runs out from Mulmur, beyond the 2nd line of Tosorontio. Its margin, as just defined, is the 160 feet shore-line, and the Algonquin itself, is some two miles farther east. The name of this projection is derived from the timber which prevailed upon it, but which has since been removed, yet countless young oak trees are now to be seen on the high ground. The southern faces of the Oak ridges, are very steep and sandy, the material having been washed over by a strong and higher water, whose surface would be some 230 feet above the Algonquin. Another conspicuous recess along the south of the Oak ridges, runs far into Mulmur.

THE PINE PLAINS.

Starting from the apex of Cornhill, in Sunnidale, the Pine plains extend in a S.E. direction, and cover portions of three townships. In shape, the plains have the outline of a beaver tail with a length of ten miles, and a breadth of seven miles at the widest part, and form an immense sand-pit of the Algonquin, with perhaps a little subsequent alteration by winds. Yet wind-blown sand is not commonly seen over this tract. The Pine plains were covered originally with a red pine forest, which was removed many years ago, and the land being too poor to cultivate, they are again thickly covered with a second growth of that timber.

Crossing the Pine plains along the town-line between Sunnidale and Tosorontio, we find the land unoccupied and unfenced from the end of the line near Glencairn, for some miles eastward along the Tosorontio side, or as far as the 7th line of that township. On the Sunnidale side there is a conspicuous range of sandhills, about half a mile from the road and almost parallel with it. These sand hillocks run through concession I, Sunnidale, and all the way through lots 6 to 11, beyond which the range passes out of Sunnidale at about lot 12, into Tosorontio at lot 33, concession VI. In the former township a few settlers have located here and there along the town-line. This range of sandhills is doubtless the main axis of the whole spit from Cornhill, though it seems to have been deflected a little to the leeward side of that locality and comes more directly, in appearance, from the large island near Cash-town. This axis of sand dunes is the part of the plains that has a more wind-blown appearance than any other, and in this respect it resembles the much higher range of sand dunes near the mouth of Nottawasaga river, the latter being the product of a lower strong shore-line. Crossing the Plains by the road from Lisle to Angus, we

find along the eastern edge of the Plains, near the latter, lake terraces, made by shore-lines lower than the Algonquin.

Travelling southward from Angus, the sand continues until the West Essa ridge is reached, six miles distant. For about a mile after leaving Angus, the surface of the land looks as if the sand had been drifted by winds.

Shells at
Angus.

No shells or other organic remains have been found during my excursions or observations on these Plains. The shells collected by Prof. Chapman at Angus (Geology of Canada, 1863, p. 910), and by Prof. Coleman (Trans., Canadian Institute, vol. VI., 1899, p. 40), were taken from the lake beds of lower and more recent bodies of water than the Algonquin, whose shore-lines are mentioned in the preceding paragraph.

UPPER CANYON OF THE NOTTAWASAGA RIVER.

Canyon in the
Algonquin.

Through Tecumseth and Essa the Nottawasaga river, for 20 miles along its course, has cut a canyon in the deposits made by the Algonquin, thus affording good sections. The silted plain—the bed of the ancient Georgian bay near its head—has been given different names in different parts; but the Essa Flats is the term applied to the greater part of the land through which this canyon has been made. Usually, the course of this canyon is too far from the shore-line itself to contain any stones or gravel; at any rate, I have observed nothing but stratified sands and clays at the places mentioned below. The superficial deposit is almost always a reddish sand. Beneath this, to a depth of several feet, are beds of a whitish or gray sand, which gradually becomes finer as one descends through the layers. This finally passes into clay, and in the lower parts of the canyon it becomes a stiff blue clay. The latter is impervious to water, so that along the low parts in the canyon, water oozes from the layers of clay and trickles down to the river. Of the many beds exhibited in the sides of the canyon, each layer may indicate a year's growth of the deposit, the horizontal planes of cleavage showing the effects of winter or ice-covered periods. The entire deposition of material, passing from fine blue clay at the bottom to coarse sand at the top, shows unmistakably a falling water surface.

Depth of
canyon.

At the river bridge, on lot 5, concession VI., Essa, the canyon is 60 feet deep. There is a projection or shelf on both sides of the canyon, which may be seen in lots 6 and 7, sixth line, Essa. On the No. 10 side road, Essa, which the river crosses in its west half, concession

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V., the canyon is again about 60 feet in depth. There is a terrace in it 35 feet above the river, or about 25 feet below the top of the canyon. A branch that flows into the river near this point has also cut a canyon to a depth similar to that of the river. At the No. 15 sideroad, which crosses the river in the eastern half of concession V., the layers are finely exhibited. At the No. 25 sideroad there is a terrace at 20 feet below the top of the canyon. The river itself runs in a 15-foot channel at the bottom; that is, a canyon within a canyon. It would thus appear that a second terrace is forming. The canyon here is altogether about 75 feet deep to the surface of the river. This is near the deepest part of the cutting. Before the next sideroad is reached below, the land drops many feet and newer lake shores are marked against the face of the cutting.

Resuming our journey along the Blue Mountain escarpment, which this digression to examine the upper canyon had interrupted, the next prominent feature we reach is the West Essa² ridge. It formed a long peninsula during the time of the lower or main Algonquin waters, projecting seven or eight miles outward from the line of the escarpment. The isthmus lying behind the ridge and connecting it with the escarpment consists of low land, but the lower Algonquin water line does not pass south between the ridge and the higher hills in Mulmur, although the upper Algonquin, at 40 feet above the lower, appears to do so. This West Essa ridge divides the wide valley that contained the ancient head of Georgian bay into two parts, about equal in breadth, although in length they differ greatly. The village of Everett is situated at the head of the western or shorter arm, just as Angus lies at the head of the lower or Great Nipissing series of shores.

Algonquin features on the Blue mountain.

Small ridges or corrugations, with a north-west and south-east direction, occur on this West Essa ridge at lot 10, fourth line, Essa. These resemble the ridges of Cornhill and the Oak ridges in having this exceptional direction, viz: jutting up the valley, as if forced into this shape by ice. The adjacent flat formed below the Algonquin level has already been referred to under the head of the upper canyon. There is evidence that these wide tracts of ground, silted up by the Algonquin water are fossil-bearing. About the year 1898, some fossil unios, fish bones and pieces of wood or bone were found while digging a well on the Agnew farm, east half of lot 4, concession 3, Essa.

Fossils.

Along the east edge of this narrow part of the ancient Georgian bay, the Algonquin made a row or chain of some half dozen islands. They stood near the eastern shore of the water and extended from

Ancient islands.

Egbert in Essa southward as far as Thompsonville in Tecumseth. One or two at the north end of the chain were cut off from the mainland by only the upper or high water Algonquin.

Projections. Another projection extends out of Adjala, a short way into concessions 12, 13 and 14 of Tecumseth. Between this projection and the last (the West Essa ridge) a deep recess runs into the face of the escarpment, with an island at its entrance. This spur into Tecumseth shows much erosion on its north side and much filling on the south side. Along the town line, between Adjala and Tecumseth, opposite the 12th and 13th concessions of the latter, the hills are covered with a deposit of sand for 40 feet and more above the lower Algonquin. On the same town line, from the 11th to the 12th line of Tecumseth, wave-built sand ridges, a mile in extent, occur. This chain of ridges looks like the remains of a sand spit issuing from the corner of the above-mentioned spur of high land. But the Nottawasaga river, which runs close to the spur, seems to have cut away that part of the spit nearest the land from which it was derived. A long arm passes down the south side of this spur and runs far into Adjala. It is known as the Adjala Swamp, and the lowest Algonquin shore line is well marked along the sides of this swamp and entirely around it. A very strong example of the main Algonquin cutting occurs in lot 22, sixth line, Adjala, although this is far inland.

Skeleton of a mammoth. On the Haffley lot, west half lot 14, concession VI, Adjala, J. Henry Peck of Stanley, N.Y., found, in 1887, parts of the skeleton of a mammoth. This is the only instance known to me of mammoth bones having been found in the Georgian Bay basin. One of the molars is in Elmira College, N.Y. The other bones are in the Geological Museum of Lafayette College, Easton, Pa.

At this southern extremity of the ancient Georgian bay, the other bifurcation passes to the north-east for a long distance through Tecumseh, West Gwillimbury and Innisfil. The ridges on the land bordering this long sweep, commencing at Bailey's creek in Adjala and passing along both sides of it, are regularly disposed toward the north-east.

In Tecumseh and Adjala. At Beeton on No. 10 sideroad, another recess occurs occupied by a considerable stream, running to the south-west. In this vicinity, and through Tecumseth generally, and in part of Adjala, the upper Algonquin, at 40 feet above the lower, is a strong shore-line, and the land in the zone between the two shore-lines shows a large amount of washing and flooding. In the time of the upper Algonquin level of 40 feet above the main Algonquin, the Georgian bay had a much further exten-

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sion southward in many places hereabout, than during the latter. Where the No. 15 sideroad crosses the main Algonquin, there is a well developed water-cutting a few rods south of the ninth line. A mile south of this much of the land was washed by the 40 feet higher Algonquin.

Farther east, at No. 5 sideroad, West Gwillimbury, on the north half of lot 5, concession XII, the Algonquin is a wave-built shore. Sand-blown reefs also occur here. A curious little stack-like island occurs in lot 5, concession XII. The Hamilton Branch Railway follows the Algonquin beach for two or three miles, through Tecumseth. A shore-line is visible in a narrow ravine at No. 5 sideroad, third line, Innisfil, and it also occurs on the north half of lot 6 in concession II. At the latter place, it is so well marked, with a much washed plateau or water-plain beneath it, that its identity with the Algonquin high-water (40 feet) cannot be mistaken. Looking north-east from the second line, this water-plain is so strong throughout lots 7 and 8 that it is clearly seen to be the early or upper stages of the Algonquin. Another similar water-plain, with gently rolling surface, occurs in lot 11, concession V.

There is a distinct bar, higher than the main Algonquin, across the valley of Bear creek, near the fourth line, Innisfil. This bar crosses the entire valley, with the exception of an outlet or break of 40 rods at the west side. But the streams do not now go through this outlet, having made another breach farther east. This bar shows a perturbation of some kind in the rate of subsidence of the Algonquin waters. In fact, the bed of this entire arm, some 20 miles in length, all silted up to within a few feet of the main Algonquin, would amply repay a more detailed study than I have been able heretofore to give it, and would show the phenomena of the subsidence, better than many features in other parts of its course.

Another low bar across this valley at the north half of lot 12, concession V, Innisfil, is one of importance, as it is the watershed of the stream flowing north and south. Hewson's or Beaver creek flowed northward through this valley into Kempenfeldt bay, but the Algonquin shore-line did not pass through it, although the 40 feet one may have done so. In any case, the bed of this brook was flooded land in Algonquin times, even if its altitude should prove to be a few feet higher than the main or lower shore-line. This flat, like others, shows a record of the subsiding stages of the Algonquin.

Returning now to the channel that divides the mainland in South Simcoe from the archipelago in North Simcoe—the Colwell and Barrie channel.

channel—where we left it some time ago, we find that along the south side of this channel the Algonquin is chiefly wave-built and is not now conspicuous, as the sand of which it is formed is loose and changeable. The first hill south of Allandale is a sand spit, except at its base. It is perhaps a little wind-blown, especially toward the top. Eastward from Allandale, there is an extensive deposit of gravel lying across the recess now occupied by Whiskey creek. The Northern Railway Company used these gravel beds as ballast for many years. The creek itself has cut a canyon through the deposits to a depth of some 50 feet. Similar canyons have been cut farther east by Hewson's or Beaver creek, and by Hewitt's creek, both of which flow northward into Kempenfeldt bay.

Most easterly
extension of
the Algon-
quin.

The most easterly extension of the Algonquin in this part of the county, viz., near Big Bay Point, is not so sharp a projection as the present shore of Lake Simcoe, but there is evidence that a considerable part of the old promontory was crowded away by the Algonquin water which being larger was much more active than the present Lake Simcoe. Along the south side of Kempenfeldt bay, the Algonquin is a cut-terrace most of the way.

Southward, at the seventh line, a little north and west of Nantyr, a well marked example of the 40 feet higher or upper Algonquin is seen. In a few places immediately south of this, the shore-line next above the main Algonquin passed through channels into the long arm of Bear creek, westward. In one of these cross-channels south of Churchill, in the third concession, many ice reefs may be seen on lot 16, looking as if small glaciers had lain in the valley and left miniature moraines.

Bradford.

The Northern Railway (a branch of the G. T. R.) follows the Algonquin beach for 12 miles northward from Bradford. Another long arm extends several miles southwest from Bradford, and is drained by the Holland river. This arm is much silted up, the upper deposits being the reddish sand so peculiar to the Algonquin lake bed. The Algonquin beach leaves Simcoe county in this arm, but it may be observed that through the northern part of York county it makes a series of long arms like those in Simcoe county. This will conclude our survey of the shore-line in this direction.

THE INSULAR TRACT IN NORTH SIMCOE.

Archipelago
in North
Simcoe.

The Algonquin lake in North Simcoe contained an archipelago of large islands. We shall make a tour around this island group, beginning at Barrie and passing west, then north.

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In a sand pit on Anne street, Barrie, there are waterlaid sand deposits, for fully 30 feet above the Algonquin, with apparently ripple marks in the sand layers. These deposits are probably due to the upper Algonquin, some faint traces of which appear on the surface in the neighborhood, a little higher up than the deposits. When sinking artesian wells in this town, which are readily had anywhere below the Algonquin level, the same story is always told by the materials passed through. These are coarsest at the top and shade into finer, as one descends, until at a certain depth, varying according to locality, but 68 feet at the town waterworks, the finest clay ends. This order indicates a falling water surface in which the materials were laid down, in accordance with the rule furnished by common experience.

At the west end of the channel that divides the Algonquin main-land in South Simcoe, from the above insular tract in North Simcoe, a great spit of gravel shading into sand, runs out from the shore-line southward as far as Colwell station, and it is commonly known as the Colwell spit. In the low ground a little east of the spit, some red sand or marl is found interlaid with layers of grey marl. West of the spit the land remains high, nearly level with the top of the spit. The railway company (G.T.R.) has a large gravel pit in these beds.

Dividing
channel.

From this place northward through Vespra, then eastward, there is a continuous cutting some seven miles in length. This cutting continues to increase in depth all the way from near Colwell, until at or near the 9th line of Vespra it attains its maximum. Here it is a little more than 200 feet in height above the terrace at its base, and as steep as its clayey materials will permit. It would be difficult to find among shore lines, ancient or existing, a finer example of shore cutting. It faces the north-west, and evidently received the full force of the Algonquin lake or sea from that direction, the sweep being unbroken from beyond Port Arthur on the present Lake Superior to this point.

Great sweep
of water.

The materials dragged down from the cliff by the active shore-line have been chiefly deposited under the old waterline in an immense filling. This has a width of half a mile or upwards in a few places. The cutting has been so extensive that all the shore-lines immediately above the Algonquin have been completely worn away. But in lot 15, concession VIII., Vespra, at the edge of an Algonquin bay, about half-way up the cliff, or rather more, a fragment of a strong lake terrace is to be seen at about 160 feet above this shore-line. It is quite conspicuous, as it enters the bay, but further outward it is completely worn off.

Midhurst. Eastward from this locality plains extend for a few miles, similar to the Pine plains in Sunnidale and Essa, but smaller. These are situated chiefly in the Vth and VIth concessions. Their formation is gravelly, and a road leads along their highest crest from Munro's creek to Midhurst, a distance of about two miles. The source from which this extensive deposit of Algonquin materials was taken was evidently the high cutting farther west. Some prominent sand dunes are to be seen in concession IV on lots 14 and 15, the materials of which have evidently been drawn from the same source, but being finer they have been carried farther. An exposure in Algonquin deposits on lot 10, seventh line of Vespra, shows a marly substance interstratified with sands. These deposits are Algonquin materials washed to leeward from the top of a hill north-west of the place.

Willow creek. The lower or main Algonquin beach extends a long way up the valley of Willow creek into Oro township, and the upper or 40-foot beach much farther. High ground bounds the east side of the Willow creek in Vespra, and against this the Algonquin water made a cut-terrace all the way. This extends northward and eastward as far as the lot 30 sideroad in concession II. A gravel spit is thrown from this across the opening into another bay eastward.

Near Craighurst on the Penetanguishene road, the land has a washed and levelled character for many feet above the main Algonquin, as high up as the 40 feet shore-line. It resembles some examples in the south and west of the county where the lake is better developed than it usually is in the 'Insular Tract' of North Simcoe. The steepness of the hillsides appears to be the cause of the difference.

Various
ancient
islands.

The south-west end of the first large island to the left comes into the north side of Vespra, and presents some interesting features. In the east half of lot 2, concession VI, the shore-line has diffuse gravel spits or deposits. Crossing over to the other side of this island's extremity, on the townline between Flos and Vespra, on lot 8, concession I, Flos, there is a desert of sand dunes. But the main Algonquin, a little further west, is quite distinguishable by its water-bearing character on lot 9.

From the extremity of the island farther east, there runs to this place a spur, which the Algonquin did not completely wash away, but made breaches through it. This chain of remaining fragments is higher than the main Algonquin, which is clearly marked along the south face of the broken spur. Its boulder belt is quite wide and at 60 feet lower, there is a deposit of the usual red sand. The latter is on the sloping

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land southward. This worn chain extends through lot 2, concession VI, and the shore-line itself runs westward a few rods into lot 2, concession VII.

Following the west shore of this island northward into Flos, a break is found in the island in the IIIrd concession. At this place it is divided into two parts by the upper Algonquin, but not by the lower. Here, the upper went through lots 1, 2 and 3, concession III, Flos, and a resulting sand plain, showing much flooding, passes through these lots. The south edge of this channel was near the third line, and the north edge near the fourth line. A little to the north-west from the western entrance to this channel, viz., half a mile north of Fergusonvale, there are deposits of the red sand at about the usual interval of 60 feet below the lower beach.

Along the fifth line, running far into the ridge of high land on the northern part of the island, there is a gully or deep recess extending as far east as the Base Line, and containing the upper Algonquin. Immediately north, there is a conspicuous feature of the shore-line, in lot 4, concession V, in the shape of a prominent nose or headland extending further west than the general course of the shore-line. Its sides are bold and cliff-like. There was a submerged bar or low ridge running out from the last mentioned headland, which at the present time appears to form a watershed between the drainage to the Notawasaga river and that to the Wye. The bar is to be found on lots 3 and 4, concession V, Flos.

In the more westerly parts of Flos, some submerged features of the shore-line are worthy of our attention. There is a considerable train of boulders, running for about two miles through lots 12, 13, 14 and 15, concession III, Flos, in a north-easterly direction, the usual course of the ridges in this county. On close inspection, this train is seen to be the top of a former ridge, which was washed over by the Algonquin. The ridge, as it now stands, is a few feet below the Algonquin water-line. South-eastward from this ridge, heavy sand deposits are to be seen, which were evidently worn off its summit by the Algonquin water. Through these deposits, Marle creek has cut a considerable canyon.

There is another, though less prominent ridge of boulders mixed with clay, on lots 15 and 16, concession IV, Flos, which also runs to the north-east. The same low ridge, with its water-holding clay-beds mixed with some boulders, is also observable on another road, viz., on the north half of lot 17, concession III. This was evidently the crest of another ridge, the stoniest part of it having been the main crest in

Township of Flos.

Features formerly submerged.

Ridges.

Algonquin times. South-eastward from the crest, the usual sand deposits are to be seen. To the north-west, the materials are first a fine sand, which soon shades into clay, the land sloping gently toward the north-west. Another stony crest is seen on the north half of lot 15, concession VI, near Crossland, from which the land again slopes gently north-westward.

Bouldery
crests.

The bouldery crests that we have just been passing in review are evidently the highest parts of a considerable ridge running through this westerly part of Flos, but the Algonquin waters had planed off all the irregularities of its surface. A little to the eastward of the crest above mentioned, I observed the deposits of red sand on the eighth line, opposite lots 8 and 9, situated at the usual depth of 60 feet below the waterline of the main Algonquin beach. In some respects this water-planed ridge through western Flos is a continuation of one running through the township of Sunnidale, which has the same altitude as the Flos part of it, viz., within a few feet of the Algonquin

Minesing hill. shore-line. The Minesing hill in Vespra also comes under this class of phenomena. It has a boulder train a little south of Minesing village, eastward from which, about a mile, there are immense deposits of gravel, carried out of the crest and thrown over the leeward side of the shoal, while the ridge was actually in the Algonquin water. The last mentioned gravel deposits are crossed on the road from Minesing village to the station. All these crests in Sunnidale, Flos and Vespra, and some in Tiny, as we shall presently see, show the enormous force of the Algonquin lake in washing off the tops of so many shoals, and the large amount of work done by that body of water in the transportation of materials.

Question as to
ice-covered
surface.

On water-worn ground like that we have just been considering, the country assumes a very gently rolling aspect, and in some places it becomes nearly a dead level. No sharp glacial features are left on land that has been washed over by so powerful a physical agent as the Algonquin lake, but many phenomena show that the Algonquin was followed, as well as preceded, by an ice-covered surface, but at the time of the greatest action, and the cutting of the enormous shore-line itself, the surface was tolerably free, at least from ice of a thickness great enough to leave many enduring marks.

Ridge with
boulders.

On the No. 18 sideroad, half-way across the IVth concession, Tiny, there is another washed ridge with a crest of boulders. Northward on the same road, half a mile, at the crossing of the 5th line, there is a sand-plain with small sand dunes from another washed crest further northward. Another series of washed crests occurs around St. Patrick.

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This is the top of another ridge, distinct from those I have described, and also distinct from the High Algonquin island a little eastward, known as the 'Mountain.' As one passes north on the No. 13 sideroad, he first encounters the washed boulder trains half-way across the VIIIth concession, and they continue northward for four miles, with but two interruptions. The first stony tract continues north for two miles, viz., into the Xth concession. Afterward, a continuation runs north of the eleventh line and there is another boulder-crowned ridge between the eleventh and twelfth lines, the stony pavement continuing northward of LeFaive's School on lot 13, concession XII. These boulder trains run in the usual direction, viz., north-east. They were evidently shoals in Algonquin times. The boulders cease altogether, half way-north in the XIIth concession, and there the sand begins.

A high gravel ridge lying some distance off the 'Mountain,' from which it is separated by Lannigan's lake, begins on lot 9, concession II, and runs north-east. It looks like a large spit; at any rate, the materials of which it is formed are lacustrine, not glacial, and they probably came from the boulder tracts toward the south-west that we have been considering, rather than from the 'Mountain.'

The 'Mountain' was a high island in Algonquin times. There are boulder pavements around the greater part of it, especially along the south and east sides, where the boulder belt is broad. There is a steep descent or cutting of nearly 250 feet at Bateson's, on the north side, through lot 108, concession II. The 'Mountain.'

We come now to the three large outer islands of Algonquin times, and it would be hard to find more interesting features than these in connection with ancient lake phenomena. Like the 'Mountain' just mentioned, they are all encircled almost completely by cuttings. These cuttings attain a remarkable height in some places; along the S. E. face of the Randolph ridge, the most southerly of the three, a cutting has a precipitous height of about a hundred feet, the slope being as steep as the clayey materials will admit. Still further, the outlines of all of them have a smooth, rounded character when correctly delineated on a map, (i.e. the protuberances of land were all worn off), as compared with the shore-line in other places, where bays and projecting points of land are common. Three outer islands.

Along the south side of the Randolph ridge, there is a broad shelf made by the shore-line. Vent's road, deflected to join with the thirteenth line, passes along this shelf and affords a good view of the 'lake-cliff.' On No. 13 sideroad, in the north half of concession XIII, the strong

cutting has beneath it a boulder pavement running half a mile south to where the sand beds occur.

Westernmost
island.

The westernmost of the three islands mentioned above extends for some distance north of Ste. Croix, and I will call it the Ste. Croix ridge. It is a little more than a mile in length. There is a strong terrace around the whole of the island, and immediately west of Ste. Croix, on the 18th line, the boulder pavement is very extensive. One cannot witness this phenomenon without being struck by the enormous amount of lake shore action that was necessary to form this boulder tract. South of Ste. Croix the boulders extend for half a mile, i.e., half way across concession XVII. At the north end of the Ste. Croix ridge, on lot 18, concession XX, there are sand reefs and boulder pavements.

Effects of
currents.

The three large islands just mentioned lie, with respect to each other, at the corners of a triangle. The intervening space partly inclosed by them contains a network of immense sand bars, formed by the currents and counter currents passing through the group. This is a very interesting phenomenon in connection with a study of the circulation of currents amidst islands, and the formation of sandbars. These bars all have lengths of two or three miles, according to their positions. One runs from the north-east corner of the Randolph ridge toward the little island lying off the most northerly of the large ones. The course of this bar is almost due north and south. At the corner of the seventeenth line and the No. 8 side road it makes an extensive sand plain. Another runs from the same extremity of the Randolph ridge in a north-westerly direction, towards the centre of the space between the islands. This crosses the seventeenth line at the boundary between lots 12 and 13. On the same line, at the boundary between lots 15 and 16, where a by-road leaves it for Thunder Bay, the summit of another bar or watershed is found, which has passed diagonally through lot 17 from the Ste. Croix ridge. Two bars or divides join here, namely, the one just mentioned, which continues south-east to the Randolph ridge, and another from the extremity of the large island to the north-east.

Horseshoe
island.

An Algonquin island in the township of Tay presents some interesting features. In shape it is not unlike a horseshoe, and it incloses a marsh of about 75 acres in lot 86, concessions I and II. An Algonquin spit extends across the open side of the shoe, and it doubtless shut off in this pocket a small extinct lake. The Algonquin beach is a strong shore-line within this bay, on lot 87, concession I. The north-east face of the horseshoe island was much washed off by the Algonquin waters. The resulting tract of stony ground near Elliott's Corners has an extent of two miles, and is quite swampy, although covered with a pavement of boulders.

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The next two islands, southward, lie close together. The channel Two islands. between them is now occupied by a branch of the Hogg river, the course of which, as well as the channel, is almost due north and south. The north end is the wider of the two. Across this end there is a gravel spit and wave-built formations extending for the two miles by which the islands are separated. The gravel spit is in lot 3, concession III, Tay, and it is cut through by the Hogg river.

Into the westerly of the two islands last mentioned, which is kidney-shaped, a bay of the Algonquin runs inland near Waverley, opening toward the north. This bay or pocket extends across the boundary of Tay into Medonte, on lots 75 and 74. The shore-line it contains appears to be the 40 feet Algonquin. The townline crosses the sandy bed of this bay, and through the bed run streams at some seasons of the year, but they are dry in midsummer. Northward the plateau of this bed soon drops about 50 feet to the lowest strands of the Algonquin at Dawe's creek.

Off the north-east point of the large Algonquin island, the most Great easterly of the two just considered, there is an extensive patch of denudation. boulders, viz., on lots 5 and 6, concessions VI and VII, Tay. The denudation of earlier formations here was enormous. Similar tracts of denuded boulders lie at the north-east of the next large island to the eastward of the last. In fact, the sides of the islands exposed to the north-east all show an immense force of the waves coming from that direction. This is true along the whole line of this row of large islands, where they face the north-east.

The last named island, which I have called the Rosemount ridge in Rosemount my archaeological reports of these townships, has a total length of 12 ridge. miles. On this island, along the Xth concession of Medonte, lots 17 to 20, the ground everywhere above the Algonquin, as high up as the 110 feet shore-line, is very much washed, and there are some sandy tracts, perhaps the result of the washing, as elsewhere. At the south-west extremity of this large island, a spit issues from it in the Ist concession of Medonte, about lot 48 or 49. It consists of gravel, nearest the ridge, and gradually shades into sand. The Sturgeon river makes its way through the sandy part of this spit. Some sandy hillocks are to be seen west of the river. Lying off this large island in the Cold-water river valley a small island of some 200 acres is quite prominent, chiefly in the VIIIth concession.

The next in order, Algonquin Island, which is by far the largest of Largest the whole group, covering some 120 square miles or more, is a complex island. congeries of ridges. At the N.E. extremity of this large island, near

the village of Warminster, a very strong cutting is found along the north edge of the ridge, through lot 10 in the XIth, XIIth, XIIIth and XIVth concessions of Medonte. It passes into the township of North Orillia in lot 9.

Bays in the large island.

Near Coulson, a considerable bay of the Algonquin lake runs some distance south into the large island. The most southerly reaches of this bay are occupied by the upper Algonquin at about 40 feet above the main Algonquin beach. The upper one here has the same character as in other parts of the county, being the general limit to which the washing extended. An enormous spit of the main Algonquin occurs on the northern part of lot 4, east half of concession VII., Medonte. It juts out from the high ground at the east side, along the face of which there is a great cutting. The spit runs nearly across the mouth of the bay just mentioned. Immense sand plains occur here in the old bed of the Algonquin lake, extending from the vicinity of this spit to the small island above mentioned.

Another bay runs south along the island between concessions III and IV, into Oro township. At the west side of the entrance to this bay, in the east half of lot 2, concession III., Medonte, two shore-lines are visible at 40 feet and 70 feet above the lower or main Algonquin. A little distance westward the main Algonquin emerges from beneath the debris and becomes, as usual, marshy along its course, with very strong springs issuing here at its water-line.

Strongly marked shore-lines.

On the second line in both North and South Orillia, and westward of Marchmont the higher shore-line at 40 feet above the lower, and even the one at 70 feet, are strong, and show a large amount of wave action, like all the shore-lines along the north-eastern faces of these islands. An example of great washing action, leaving a gravel hill-top, occurs a few rods east of Marchmont village on the crossroad. Altogether, in the Marchmont district, the parts of the Algonquin become much differentiated, and it is no easy task to identify the main shore-line everywhere. The collateral shore-lines, both above and below it, introduce elements of confusion, but there are certain places where it is well defined, and by reference to these places it can be distinguished from all the others.

Archipelago in Orillia.

There was an archipelago of Algonquin islands, smaller than those we have been hitherto examining, in the townships of North and South Orillia. The outermost has a length of three miles, and has a very strong cutting around it, especially in concessions VI, VII and VIII, of North Orillia. The land on this island is very stony and much washed, both above and below the Algonquin; but the strong cutting

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of the main Algonquin is unmistakable, and easily distinguished by its strength from the other shore-lines. It attains an altitude here of about 155 feet above Lake Couchiching, or about 875 feet above sea-level. The uppermost shore-line in the series below the Algonquin, sometimes known as the 'Great Nipissing Series,' becomes a strong shore-line in these outlying parts, at about 60 feet below the Algonquin.

On the No. 9 crossroad, South Orillia, there is a strong Algonquin cutting a few rods west of the third line. The shore-line here is distinctly double on the same hillside, the upper showing out well at about 40 feet above the lower. It is also seen to be double south on the 2nd line in lot 11; and both strands are distinct in lot 10, looking south-east from the corner of the 2nd and 9th crossroads. On the west half of lot 21, con. XIV, Oro, the next lower shore-line is well cut at 60 feet below the main Algonquin. From near this place, the Grand Trunk Railway follows close to the Algonquin for nine miles, to the IVth concession of Oro.

GENERAL CONCLUSIONS.

Upon the whole, I do not see much reason for calling the Algonquin, a glacial lake, as many writers do. Farther inland, i.e. westward, it might have been semi-glacial, but in this part of the country (Simcoe county) the evidence proves exactly the opposite, viz., that but little ice interfered with its intense activity, although there were tranquil periods before as well as after it, during which there was thick shore ice of a sub-arctic character.

The ice dam theory of Prof. Newberry has been extensively employed to account for Algonquin phenomena. But along the north-eastern parts, where the glacier or ice dam is supposed to have rested, and where the shore-line might be expected to fail to give us evidence of its presence, the drift deposits being necessarily covered up with the hypothetical glacier, it is just where the shore-line has its most distinct development.

The cause of the great strength of the Algonquin beach is a proper subject of inquiry, on the basis of our observations along the shore-line. Its formation and subsequent preservation would seem to have been the result of an oscillation of climate. If it had not been preceded by an ice-covered calm sea, as well as followed by a similar one, the record it left on the ground might have been different. The eroding edge of the water body had a chance to mark a strong line, which it did with great energy.

Perfection of preservation.

What strikes one most forcibly everywhere, is the perfection with which the superficial formations just beneath the level of the Algonquin shore-line have been preserved. Had the activity of the shore-line period been maintained as the water surface subsided, greater changes would have been wrought in the lake deposits of an earlier date. But we find them almost intact, just as the Algonquin water left them. Unless the subsidence was instantaneous, which is not at all probable, we cannot escape from the conclusion that a tranquil ice-covered sea succeeded the Algonquin for a long period. There are evidences upon the ground of such a sub-arctic period.

Difficulties in correlating different shore-lines.

These observations furnish us still further with evidence that here, within the compass of a single county, the character of the shore-line varies from other causes than the configuration of the land it met with. Its great strength along its north-easterly exposure contrasts with its less intense, though still strongly marked, features along the base of the Blue Mountain escarpment. How futile then are the efforts of some geologists to identify shore-lines found at different places, widely separated, not merely by the width of a county but by hundreds of miles. Supposed absence of shore-lines is accounted for by the presence of glaciers. Oscillations of climate may ultimately be found to be the safest guide in attempts at identification of shore-lines or their equivalents in different localities. When the climatological characters and other phenomena connected with shore-lines shall have been properly investigated, the superabundance of theories, mostly conflicting with each other, may be expected to resolve themselves into distinct knowledge.

AN INVESTIGATION OF THE COPPER-BEARING ROCKS OF THE EASTERN TOWNSHIPS, PROVINCE OF QUEBEC.

Principal J. A. Dresser.

Copper-bearing rocks of Quebec.

The time from June 23 to August 30 was spent in an examination of part of the copper-bearing rocks of the eastern townships of the province of Quebec. These rocks have received more or less attention from the Geological Survey since 1847, specially important reports having been made upon them by Sir William Logan in 1863, by Jas. Richardson in 1866 and by Dr. R. W. Ells in 1888-9. In these reports the copper-bearing rocks were shown to form three principal belts, having a general north-easterly trend in agreement with the main axes of folding of the Appalachian mountain system, which is here represented by the Notre Dame mountains. Throughout a considerable part of their known length these belts are about 25 miles apart and are themselves generally from 2 to 10 miles in width. The

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most westerly has been called the Acton belt, the second the Sutton and the third the Ascot, from townships in which they are largely developed.

According to your instructions of May 27 last I was directed to examine a part of each belt with a view to eventually making a detailed study of the more important areas, and of determining their petrographical relations and extent as completely as possible. The Acton belt was first cursorily visited. Specimens of the country rock and of the intrusives which accompany the various deposits were taken at Wickham, Acton, Upton and Roxton. Three days were thus spent, in which I was much assisted by the Rev. L. C. Wurtele of Actonvale. The Sutton belt was next examined in a similar manner from Knowlton to the Vermont boundary line. The deposits at S. Sweet's, D. L. Smith's and the Sweet mine in Sutton, as well as the lesser mines on the south side of St. Armand Pinnacle were visited, and the main ridge of Sutton mountain, known locally as the 'Round Top,' was crossed in two directions. In this I was kindly aided by Mr. H. A. Honeyman, M.A., of Knowlton, whose familiarity with the geology of the locality was especially valuable. The eastern base of Sutton mountain between Glen Sutton and Mansonville was also examined in order to ascertain whether or not the copper-bearing rocks which form the western side, but do not extend to the more elevated parts of the mountain, re-appear here. It was found that they do not. Some extensive development work having recently been done at the mines in West Berkshire, Vermont, 4 miles south of St. Armand Pinnacle, a half day was spent in visiting them. These mines, which are the property of the Vermont and Boston Mining Company, repeat the conditions of the St. Armand and Sutton deposits and afford some of the best opportunities of noting the mode of occurrence of the copper observed in the study of the Sutton belt. I was courteously directed in visiting these mines by Mr. H. E. Rustet, Richford, Vt.

Localities
examined.

The examination of the Ascot belt was begun at North Hatley, whence the Suffield, Eustis and Capelton mines were visited. Then after three days spent in the vicinity of Lake Megantic, to which reference will be made later, the Ascot and the Victoria mines near Capelton were visited, as well as some apparently smaller deposits on the east side of the St. Francis river. A camping outfit was then procured at Sherbrooke, and I was joined by Mr. A. P. Stevens, B. Sc., who had been assigned by you as my field assistant, and by Frank Graham, who was engaged as a general camp hand, and who also proved a most serviceable helper. Beginning in the fifth range of the township of Ascot Corner, the ridge of hills known as Stoke mountain

Camp outfit.

Other places
visited.

was examined in as much detail as the nature of the country permits, to its eastern extremity near Dudswell pond, in the township of that name. The ridge between the St. Camille and South Ham roads, which forms the topographical continuation of Stoke mountain, was followed as far as Silver lake, and was crossed at various places for a distance of eight miles. Some copper deposits recently opened in the vicinity of Lake Weedon, were also examined at this time.

Sutton belt.

The camp was broken up on August 17, and in the time remaining I proceeded alone to visit the more important of the known deposits of the Sutton belt in its northern extension in the townships of Leeds, Halifax and Chester. A reputed occurrence of copper at St. Nicholas, was also visited, and a few days were spent in the examination of some important deposits of copper-bearing pyrrhotite on the west side of Lake Memphremagog. This, with a few separate days spent at Melbourne, Upton and Ascot, completed the field work of the season.

The Acton belt.

The Acton Belt.—The principal occurrences of copper that were observed in this belt were those long known at Wickham, Acton, Upton, Roxton and St. Pierre de Durham. The country-rock in all cases is limestone, generally in association with black shales or slates of sedimentary origin. Igneous rocks in the form of small dykes or irregular masses occur at all these places. They are intrusive in every instance as far as known, and sometimes themselves carry copper. The greater part of the copper, however, occurs in the limestone, or occasionally in the black slates, near the intrusives. The ores vary with the different localities. At Acton, bornite and chalcocite predominate, while at Upton, chalcopyrite and chalcocite are the chief ores, bornite being rare. Native copper is said to occur at the latter point, but I was not able to find any.

Similarity of intrusive.

A feature of interest, as well as of possible importance, is the apparent close similarity between some of the intrusive rocks in the Acton belt, and the latest dykes which are found at the Eustis mine in the Ascot belt. In the latter case, however, the country-rock is a very old eruptive, and is itself the copper-bearer. The Acton belt, so called, is a rather ill-defined area in the Upper Cambrian and Lower Silurian systems. The distance from Durham to Upton, which are extreme points in the width of the belt, is about sixteen miles. From Roxton to Wickham, along its length, it is only twenty miles, but copper is known to occur further north-eastward at Drummondville, Wendover, Somerset, Nelson, St. Flavien, and, it is said, even at St. Nicholas on the St. Lawrence river, over a distance in all of more than one hundred

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miles. In the course of a brief examination of the St. Nicholas locality, I found no copper at all. An igneous rock similar in appearance to that which carries copper in the vicinity of Lake Weedon, in the eastern part of the Ascot belt was found, however, in considerable quantity. In the Acton belt on the west side of the St. Francis river there are also reported to be several smaller deposits of copper, as at St. Theodor d'Acton, St. Valerien, and in Danby, some of which are now receiving attention and are said to give considerable promise.

Although many of these copper localities are near the contact of the Cambrian rocks with those of Cambro-Silurian age, others, including some of the most important, occur within either formation. Hence they may be looked for anywhere over this long irregular area wherever intrusive rocks are to be found. The geological structure apparently gives no clue to the occurrence of the intrusives. The eastern part of this belt, between the St. Francis and the St. Lawrence rivers was, as has been said, not examined, except very briefly at the single locality of St. Nicholas. While it is not a region in which rock exposures are numerous, yet the rapid deforesting of the country in recent years and also the extension of the Intercolonial and the construction of the Megantic and Lotbinière railways should open some new parts of this region that may be worthy of examination. The high quality of the ores in this belt gives an especial incentive to the search for them.

Geological positions of copper occurrences.

The other copper-bearing districts of the eastern townships are more closely connected with the geological structure of the region. In the reports of the Geological Survey for 1886 and 1894 three areas of Pre-Cambrian rocks, which in previous reports had not been distinguished from the intervening Palaeozoic strata, were recognized, and their extent mapped. Two of these, the Sutton Mountain series and the Ascot or Stoke Mountain rocks, respectively include amongst their measures the middle and eastern copper-bearing belts of the earlier surveys. It is therefore a fundamental part of the present investigation to separate the copper-bearing from the other parts of these ancient rocks.

Rocks of Sutton and Ascot mountains.

To this end two facts of prime importance have been thus far ascertained: that the greater part of these Pre-Cambrian areas are of igneous, not sedimentary, origin; and that copper occurs only in, or in close association with, the igneous rocks. The latter range from volcanic to plutonic in texture, and chemically they present both acid and basic types. All are highly metamorphosed and their original characters are often much disguised, if not altogether obliterated. Their intense foliation and shearing have commonly given the rocks which

Copper ores associated with igneous rocks.

are largely fine-grained 'traps,' the aspect of much altered sediments, which they have hitherto been thought to be. On this assumption the ore bodies have been long regarded as bedded veins and so have been correlated on supposed stratigraphic grounds. In consequence of this change of view as to the character of the country rock, which a preliminary microscopic examination has established, such correlation becomes useless, and also any determination of the values of deposits based upon it. A brief notice of characters of some of these rocks was presented to the Canadian Mining Institute in March last (Journal Can. Min. Inst., vol. V, 1902) and to the American Journal of Science in July.

Pre-Cambrian
of Sutton
mountain
belt.

The Sutton Mountain Belt.—The width of the Pre-Cambrian of this belt at the Vermont boundary line is about twenty miles, some sixteen of which are of volcanic origin. Copper occurs at many places in the volcanic portion, but is nowhere found, as far as could be ascertained, in the sedimentary strata. The latter include all the ridge of Sutton mountain, which consists largely of a gneissose sandstone, and so is entirely different in origin and lithological character from the main part of the large area to which it gives its name. The volcanic area consists chiefly of a dull green 'trap' rock, of fine grained and of rather uniform character. It is often amygdaloidal and is so far altered that chlorite, quartz and epidote are the principal minerals distinguishable by the naked eye. Its precise original character has not yet been determined. It has generally been described as chloritic slate. Quartz in veins and other forms is abundant in many places and sometimes occurs in close association with epidote. The latter forms nodules, which from their greater resistance to erosive forces stand out in prominent relief on weathered, or more especially on water-worn surfaces. These nodules are often found on closer examination to consist of alternate concentric layers of epidote and quartz. They are usually from one to three inches in diameter and sometimes make up as much as one-fourth of the entire rock.

Evidence of
intense meta-
morphism.

In its unaltered state this rock was probably a rather basic one of the porphyrite or possibly of the diabase class. As the above description indicates, however, its metamorphism has been intense, and a detailed examination of the thin sections now being prepared will be necessary to determine its primary character as well as other important matters concerning it.

Certain smaller portions of the volcanic mass, however, are very different in aspect and also in mineralogical and apparently in chemical composition. They are light coloured, gray or fawn, and have a talcose feel

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which is, however, probably due to the shreds of colourless mica (sericite) developed along the shearing planes of the rock. These are the micaceous and nacreous slates of the earlier surveys. Similar appearing rocks in the Ascot belt have been found by the aid of the microscope to be crushed and sheared volcanics which would have had about the character of quartz-porphyry when in an unaltered state. Copper seems to occur more frequently in these than in the chloritic rocks, although it is found in both. In the county of Megantic they frequently carry the rare mineral ottrelite, or chloritoid, which has given them a peculiar interest to mineral collectors. Several occurrences of the corresponding facies of this rock were observed in the Ascot belt where it passes by sharp transition into the basic volcanic already described. No field evidence to the contrary has yet been found in this area, so, pending a more complete investigation, the same relation is assumed.

The ores are chalcopyrite, bornite and chalcocite, with smaller portions of blue and green carbonates, and they occur in a gangue consisting chiefly of quartz and calcite. They do not occur in true veins in any instance I have yet observed. Rudely lenticular masses seem common and frequently, either from the nature of the exposure or of the deposit, no definite form is discernible.

The volcanic portion of the Pre-Cambrian was found in the townships of St. Armand, Sutton, Brome, Bolton, Stukely, Ely and Melbourne, on the west side of the St. Francis river, and in Cleveland on the east side. In Chester, Halifax and Leeds, between 40 and 50 miles farther to the north-east, where the belt was next crossed, the rocks appear with the same characters as before. The reported occurrence of copper at many intervening points indicate that the traps are continuous in the interval. They have a width of about two miles on the St. Francis river, but, in Leeds, become as wide again as they are in St. Armand. The distance between these points is rather more than 100 miles. Within that area over 300 localities were reported, in 1866, as copper-bearing, and some 23 as actually producing more or less ore. To this number a few more important occurrences have been since added. Some of these deposits have doubtless been worked out, or have proven unprofitable under the conditions in which they were worked, while others have been discarded on very superficial examination or inconclusive tests. For two seasons Mr. W. F. E. Bowers, of Chicago, has worked a new property on lot seven of the first range of Melbourne. At my visit in June last, a shaft seven and a-half feet square was sunk vertically to a depth of 50 feet in a quartz mass, which carried copper pyrites and bornite in stringers in the quartz through about one-quarter

Nature of
ores.

Copper bear-
ing localities.

of its width. Assays of the chalcopyrite were said to give 24 per cent copper, 32 per cent sulphur; of the bornite 19 per cent each of copper and sulphur. There was also \$9 worth of gold to the ton.

Mines
reopened.

Several of the previously worked mines in this belt have been recently reopened to some extent. Amongst them are the Ely mine in Ely, the Balrath in Melbourne, and some smaller properties in Shipton, Brome, Leeds and Chester. The Pre-Cambrian belt extends some forty miles to the north-eastward of the township of Leeds, but there was not time to make any examination of it. A few reported occurrences of copper in it would, however, indicate the continuance of the volcanic rocks, and the consequent promise of the area to the prospector. This is emphasized by the fact that the most important deposit yet worked in this belt, the celebrated Harvey Hill mine, now the property of Dr. Jas. Reed, occurs near the north-eastern limit of the township of Leeds.

Igneous rocks
constitute
Pre-Cambrian
of Ascot belt.

The Ascot Belt.—The Pre-Cambrian of this area consists, in so far as it has been studied in detail, almost entirely of igneous rocks. Upon these there are occasionally found overlying remnants apparently of Palæozoic strata which once covered the entire area. They are chiefly ferruginous black slates common to the Lower Trenton formation and are found in places better protected from denudation.

The igneous rocks are essentially of the same types as those described in the Sutton belt, but their proportions are approximately reversed. In this Ascot belt the acid class—the micaceous and nacreous slates—greatly predominates over the basic type of chloritic and epidiotic rocks. The latter present no features of difference from those already described that are worthy of note. In the acid class, however, there is a greater variation corresponding in some measure to its greater extent. This is chiefly in the degree of crystallization. While the main parts of these rocks are porphyritic in structure, there are both finer grained rocks and those of coarser texture. The former are unimportant in extent, as far as yet studied, but rocks of a more advanced stage of crystallization form large areas in Stoke mountain and also appear in various other places. These granite porphyries and porphyritic granites comprise a great part of the barren, or non-cupriferous areas, though in a few instances they carry important quantities of copper.

On the west side of the St. Francis river later dykes cut the other igneous rocks; and while the latter are extremely metamorphosed, the former are but little, if any, changed in position or chemical character,

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Olivine diabase and comptonite have been found in an exceedingly fresh state, the latter cutting Lower Trenton sediments, as well as Pre-Cambrian eruptives. It is thus evident that this part of the Ascot belt at least has been the scene of volcanic activity at intervals through a long period of time, from Pre-Cambrian to Post-Trenton. Dykes were not observed in any other part of any of the igneous rocks thus far studied, nor has any other area of equal size produced as much copper as this part of the township of Ascot. While there is little but presumptive evidence that the greater metallic content of these rocks is due to successive and more varied volcanic action among them, yet the coincidence seems worthy of note.

Evidence of volcanic activity.

The Pre-Cambrian, as defined by the survey of 1886, extends from the east side of Lake Memphremagog, in the township of Stanstead, through Hatley, Ascot and Stoke townships and reappears after an interval of some 8 miles further to the north-east in the townships of Weedon and Stratford, and after a further interval again in Garthby. The position of the Garthby area, however, leaves it a matter of doubt whether it should be included in the Ascot or the Sutton belt, or whether, as is more probable, it forms a connecting link between them.

My examination between St. Francis river and Lake Memphremagog was made chiefly to ascertain as far as possible in the working mines the petrographical relations of the ore-bodies, and hence it did not extend into the township of Stanstead and only included the northern part of Hatley. Here the Pre-Cambrian was found to be largely, if not wholly igneous. Also on the west shore of Lake Memphremagog the basic volcanics again occur, having a width of nearly a mile and a half south of the Mountain House landing. They form the base of Owl's Head mountain. Four specimens described by Dr. F. D. Adams in the report of the Geological Survey for 1880-1-2, (pp. 11, 12 and 13A), appeared to be from this locality. They were altered diabase. The area is densely wooded along the lake shore and time did not permit of an examination further to the westward. The extension of the Ascot traps across Lake Memphremagog, thus brings the rocks of that belt within eight miles of the Sutton belt; whence it is not improbable that these belts may yet be found united at either end, the Ascot belt forming a chord seventy miles in length, which reaches the Sutton belt at two points about one hundred miles distant when measured on the arc it describes. The occurrence of these rocks on the west side of the lake, also adds to the otherwise promising prospects of this as an important copper-bearing district.

Petrographical relations of ore-bodies studied.

Of the importance of the area between Lake Memphremagog and the St. Francis river, I may quote from the Report of the Geological

Report of Dr.
Ells quoted.

Survey for the years 1888-9 in which this belt from Hatley to Stoke is described in detail by Dr. R. W. Ells, who mentions that of fifty-five copper localities, thirteen were actually working in the year 1865. Concerning these deposits, Dr. Ells said: 'It may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed has never been ascertained, and that masses of ore of equal importance to those so long worked will at some not distant date, by careful prospecting be found. Much of the failure of twenty-five years ago was doubtless due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness, often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of supply for sulphuric acid is being very fully realized by the men interested in this industry in the United States, their superiority over most of the ores there found, for this purpose, being acknowledged.'

Besides the well-known and extensive works of the Eustis Mining Company at Eustis, and of the G. H. Nichols Chemical Company at Capelton, the principal work more recently done has been at the group of mines at Sutfield, the Ascot and the Sherbrooke mines.

Acknowledgement.

I am specially indebted to Mr. John Blue, manager of the Eustis mine, who most courteously extended every facility for a complete examination of that extensive mine.

Stoke mountain range.

Stoke Mountain is a series of hills some three to five miles in width which rise gradually from the St. Francis river opposite the city of Sherbrooke to a maximum height of fifteen hundred feet above Duds-well pond at Bald Peak, twenty-four miles east of Sherbrooke. It is a continuation of the Capelton hills and has a like origin and a similar geologic structure. The northern side presents a serrated ridge as seen from the vicinity of Stoke Centre and is, throughout, the highest part of the entire elevation. The southern face is less elevated, but yet it is generally a quite abrupt feature of the landscape. The intervening part of the mountain, while having a general southward slope, is yet very poorly drained, and in this wet season much of it was an impassible swamp. The rock exposures in it are very few.

Iron pyrites.

The northern ridge of the mountain shows little evidence of the presence of copper. In the sixteenth lot of the eighth range of Stoke, on the farm of Joseph Tremblay, iron pyrites occurs in considerable amount in an elliptical mass some two feet thick of quartz and calcite and also in the slaty country rock.

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This locality and a somewhat similar one on lot 15, range X, of Stoke are in the Cambrian measures a quarter of a mile north of the Pre-Cambrian. They are the only occurrences of metallic constituents in notable amount that I saw on the north side of the mountain, with the exception of a small occurrence on lot 21, range V. of Ascot Corner. Mr. C. W. Maynard informs me, however, that some occurrences of pyrites are to be seen on the neighbouring hills north-west of the Wattopekah river.

The central portion of the Stoke mountain is so far drift-covered and so heavily forested that little information can be obtained regarding the nature of the underlying rocks. A few specimens were taken and will be studied in detail. But several large brooks which rise in this depression have cut deep gorge-like channels through the southern edge of the mountain and so afford excellent rock exposures there. That part of the mountain is thus shown to be a continuous mass of sheared volcanics identical in character with those of the Capelton hills. Like them also these rocks contain rusty zones running parallel to the lamination of the rock, which are due to the oxidation of pyrites which the rock contained when fresh. These rusty zones, which are important surface indications of ore deposits, are especially frequent on the Mills, Big Hollow, Harrison, Kingsley, Jenkerson, Rowe and Willard or Hall's brooks. They were also observed in several places on lot 27, of the VIIIth range, of Ascot Corner.

The occurrence of gold too seems to indicate the presence of copper Occurrence
of gold. throughout this locality, as in other parts of the belt. The relation of these minerals in the Capelton hills points clearly to their genetic connection. This is well shown at the Eustis mine. There the volcanic rocks of the copper-bearing belt rise with a steep slope on the southern side and are overlain near the crest by sedimentary slates. In a small brook which runs near the mine, I am told by Mr. Blue, the manager, alluvial gold occurs in small quantities and assays of the quartz veins which cross the brook also yield gold as far up the brook as the volcanic rock is exposed. Beyond this no gold has been found either in the gravels or in the bed rock.

Alluvial gold has been found probably in all the brooks on the south side of Stoke mountain and especially in Westbury and Dudswell, and its source has been shown by Dr. Chalmers to be undoubtedly in the Pre-Cambrian rocks. In fact visible gold occurs in the rock in a few places. These facts have generally diverted the prospectors' attention from the search for copper which the geological conditions indicate may yet be found to be the more important mineral resource of this district.

Lake Weedon
to Lake
Aylmer.

From the vicinity of Lake Weedon to Lake Aylmer the Pre-Cambrian, which is covered by Cambro-silurian and Silurian sediments from Duds-well pond eastward, again appears. Time did not permit of a detailed examination of this area which its importance seems to warrant, but a brief visit to some points west of Lake Weedon show the area to be a promising one. As far as seen it consists of an igneous rock of rather plutonic character of crystallization and somewhat resembles part of the northern ridge of Stoke mountain. It differs from that, however, in containing copper apparently in important quantities. On lots seventeen and eighteen of the third range of Weedon, iron and copper pyrites occur in veins, masses and small grains in the country rock. Outcrops of this character have been found at various places on these two lots. Other occurrences of copper are reported from different parts of this district, so that it seems worthy of detailed examination.

On the South Ham road, four miles east of Marbleton, Mr. William Mackie showed me a block of pyrites, said to have been found near a ridge which forms a connecting link topographically between Stoke mountain and the Weedon hills. This ridge was crossed in several places farther westward but was there found to be composed wholly of later sedimentary rocks. Yet, being wooded in the part of the ridge mentioned, and hence not satisfactorily examined, an outcrop of the copper-bearing rocks may yet be found in this vicinity.

Rocks of Lake
Megantic
area.

The third area of rocks of Pre-Cambrian age, which has been mentioned, occurs along the boundary line between the province of Quebec and the states of New Hampshire and Maine. It lies chiefly in the townships of Emberton, Chesham, Woburn, Clinton, Louise and Ditchfield. Its similarity in age to the Sutton and Ascot copper-bearing areas, together with the reported occurrence of cupriferous blocks in the vicinity, made it desirable to visit the locality. Accordingly the exposures along the Canadian Pacific Railway were carefully examined in Ditchfield township between Boundary and Trudel sidings; then the road from Woburn landing at the head of Lake Megantic to Channay and thence to the Arnold river; after which the road from Channay to Chesham or Notre Dame des Bois was examined. The rocks seen in Ditchfield were found to be gray volcanics essentially similar in character to those already described from Sutton and Ascot. In a cutting of twenty rods in length near the 189th mile post from Montreal the rock is everywhere rusted from the oxidation of pyrites. In the central part copper and iron pyrites comprise probably ten to twenty per cent of the rock through a belt of

Copper.

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ten yards in width. As it crosses the line of the railway at an oblique angle the width of the belt is, however, somewhat less than thus appears.

Between Woburn landing at the south-west extremity of Lake Megantic and the village of Channay, the principal rock exposure is an abrupt hill some five hundred feet high in lots 10, 11, 12 and 13 in ranges I and II of Clinton. This is locally known from its peculiar profile as the 'Scotch Cap.' Its igneous origin is denoted by the colouring on the Geological Survey map of 1886. Lithologically it is found to be identical with the basic volcanics of Sutton and Ascot. Chlorite and epidote are prominent constituents of the rock. No copper was seen in it.

I was informed by the Rev. Père Huard, curé of Channay, that bor-nite had been found on the bank of the Arnold river two and a half miles from Channay, and that preparations were being made to develop the property. As it was said that the exposure could only be seen at low water, and the water in the river being very high at the time of my visit, I did not go to the locality.

Along the road between Channay and Chesham, or Notre Dame de Bois, rock exposures are numerous and are wholly of the basic volcanic class. Rusty patches similar to those already mentioned were observed in a few places.

The similarity of these rocks to those of the known copper-bearing belts, the known occurrence of copper in Ditchfield, and the fact that chloritic and epidotic rocks have been reported by many observers in the highlands of Gaspé, point strongly to the possible great extent of this volcanic belt. It seems possible that the watershed which determines the Maine boundary line may, when the country becomes accessible for detailed examination, yet be found to form a more or less continuous ridge of copper-bearing volcanics, perhaps to be ultimately connected with the cupriferous Pre-Cambrian of New Brunswick.

Other areas.—Another occurrence of copper, which is not related in position or geologic relation to those already described, is found on the west side of Lake Memphremagog, principally in the townships of Potton and Bolton. The largest of these, the property of Mr. G. E. Smith, is about two miles from Knowlton Landing but I was not able in the time available to ascertain the full extent of this occurrence. It has been developed by sinking a shaft some eighty feet in depth while a horizontal tunnel, one hundred feet in length, cross-cutting the ore body reaches the shaft fifty feet from the surface. The course of the

Extent of
copper-bearing
belt.

The Smith
mine, Knowl-
ton Landing.

cross-cut is towards Sugarloaf mountain on the west side of which the mine is situated, and the ore body seems to be a phase of the zone of contact of an intrusive mass of the mountain with the surrounding sedimentary rocks. A curious repetition of these conditions in miniature is found three-quarters of a mile north of G. E. Smith's mine on the farm of John Burbank. Here a small intrusion of plutonic rock (granite or diorite) cuts the same sediments which border on the west of Sugarloaf and produce in a contact zone two feet in width a few inches of similar ore.

Character of ore.

The ore is a pyrrhotite said to carry a small percentage of copper. It oxidizes very readily giving a strong odor of sulphur in the shaft. The amount of sulphur, of which it is reported to carry 35 per cent, which is carried out in solution by water is surprisingly large. Drift material, fallen branches and leaves of trees are cemented together by the iron thus leached out. Several inches of this recent conglomerate are said to have been deposited since the uncovering of the ore body ten or twelve years ago. I was much assisted in the brief examination made of this locality by Mr. O. Rexford, B.Sc., of Knowlton Landing.

Similar ores occur at several places in Potton and Bolton, but no others have yet been found to be of so great extent. The occurrence of intrusive rocks is so frequent in this district, however, that a repetition of the conditions of the Smith mine might be looked for with every prospect of success amongst them. This is in fact one of the most important localities for detailed prospecting in the eastern townships.

General conditions of mining.

General conditions.—The conditions of transportation, mining and treatment of ores have greatly changed since the early 'sixties,' when active work was general in the mineral-bearing districts of the eastern townships. The decline in the price of copper has been followed, though at some distance of time, by changes of an opposite tendency. The clearing and general opening up of the country has been accompanied by the establishment of abundant railway facilities, which with the exception of the Grand Trunk Railway date subsequently to the closing of most of the mines. The Intercolonial and the Drummondville branch of the Canadian Pacific Railway run longitudinally throughout the length of the Acton belt. The latter line also runs within the Sutton belt from Foster to the Vermont boundary, passing in the immediate vicinity of the principal mines of that area, which were formerly from thirty to fifty miles from a railway. The Canadian Pacific Railway towards Sherbrooke now passes through the township

Railway facilities.

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of Bolton and further eastward crosses the boundary line in the volcanic area of Ditchfield. The Boston and Maine Railway runs parallel to the Capelton hills at their foot, while the Quebec Central skirts the Stoke mountain on its southern side throughout its length, crosses the Weedon and Lake Aylmer district, and follows the south-eastern side of the Sutton belt from the vicinity of the Harvey Hill mines to the Chaudiere river. Thus these mines, for instance, which were formerly twenty-five miles from a railway are now brought within seven.

The Orford Mountain Railway also opens an important part of the townships of Stukely and Ely in the same belt.

To these, advantages and advancement in means and methods of mining and smelting must be added. At present the only smelting works in the district are those of the G. H. Nicholls Chemical Co. at Capelton. Here custom work is occasionally done, but mill tests seem to be too rarely made in the development of smaller properties, the tendency being to rely too much upon assays of hand specimens, the method of selection of which it is always difficult to determine. A movement is also on foot to establish a custom smelter at Sherbrooke. Under all these changed conditions, therefore, the production of copper in the eastern townships becomes a new economic question, and one very different from that of thirty-five years ago when most of these mines were closed.

APPENDIX.

ANALYSES OF ROCKS FROM BROME MOUNTAIN.

(By Mr. M. F. Connor.)

	No. 4561	No. 4575	No. 4582	Rock analyses.
Si O ₂	44.00	55.68	61.77	
Al ₂ O ₃	27.73	20.39	18.05	
Fe ₂ O ₃	2.36	2.10	1.79	
Fe O	3.90	1.95	1.75	
Mg O	2.30	0.80	0.89	
Ca O	13.94	1.92	1.54	
Na ₂ O	2.35	9.18	6.83	
K ₂ O	0.45	5.34	5.21	
H ₂ O	0.80	1.50	1.10	
Ti O ₂	1.90	0.60	0.74	
P ₂ O ₅	0.20	0.06	0.15	
Mn O	0.08	0.31	0.15	
	<hr/> 100.41	<hr/> 99.83	<hr/> 99.97	

No. 4582 is a light gray or fawn coloured rock with a generally granitic structure and coarse texture. Feldspar and specks of dark mica and hornblende can be discerned in the hand specimen.

By the aid of the microscope microperthite is seen to be the greatly predominating constituent of the rock. In addition to biotite and a green hornblende, which are present in very subordinate amounts, sphene is also present with needles of apatite and an occasional grain of iron ore.

The rock belongs to about the laurokite class described by Brögger in Southern Norway.

It was formed by the second great intrusion of Brome Mountain laccolite.

No. 4575. This is a greenish-gray ingrained rock containing well marked phenocrysts of orthoclase feldspar.

The groundmass of this rock consists either of an unindividualized base or of patches of granular feldspar and ferro-magnesian material. It has yet to be studied in detail.

It forms the third intrusion of Brome mountain.

No. 4561. This is a massive rock, gray in colour, and weathering to a dull brown. The structure is granitoid and the texture medium.

Feldspar and small amounts of dark minerals, chiefly hornblende, mica and iron, can be distinguished in it by the unaided eye.

In the thin section basic plagioclase is found to make up as much as 90 of the rock. The remaining constituents are pyroxene, olivine and biotite, with accessory magnetite and apatite.

Hornblende enters into the composition of many parts of the rock in amounts quite equal to pyroxene, but in others seems to be entirely absent.

The rock passes in places into essexite and theralite, to which rocks it is somewhat closely allied. Its varietal classification will be determined when the mineral constituents have received a little more detailed study in connection with the calculation of its chemical composition.

It is the earliest of the three intrusive masses which form the igneous part of Brome mountain.

PALEONTOLOGY AND CHRONOLOGICAL GEOLOGY.

*H. M. Ami.**(A.) Manitoulin Island District.*

During the past year much time has been spent in determining the collections of organic remains from various localities in the Manitoulin Island region of Lake Huron, in the province of Ontario. Faunal lists were prepared and the geological horizon which these predicated were given.

The principal localities from which these collections were obtained by the various officers of the Geological Survey, from 1847-1898, and the geological horizons they indicate, so far as the collections and mode of preservation of the specimens permitted, are here given. The collections count no less than 184, but only the more important ones are now recorded for the sake of reference:—

THE CHAZY FORMATION.

1. In his list of the fossils from the island furthest south of the group off Point Pallideau, Lake Huron, E. Billings notes that the occurrence of *Modiolopsis parviuscula*, *Vanuxemia inconstans*, *Pleurotomaria staminea* and *Lingula Huronensis*, species known to occur in the Chazy of different portions of Ontario, notably in the Montreal-Ottawa-Champlain Basin. No evidence of the presence of the Chazy was obtained by me from the numerous collections examined, but the foregoing determinations made by Billings are undoubtedly accurate and the presence of the Chazy formation in the region in question must accordingly be recorded from the 'island furthest south of the group off Point Pallideau.'

BLACK RIVER AND TRENTON FORMATIONS.

2. Saint Joseph Island, Gravel Point, Lake Huron, T. C. Weston, 1882.

3. Goat Island, south of Lacloche Island, Lake Huron, Robert Bell, 1892.

4. Great Cloche Island, near Little Current, Lake Huron, Robert Bell, 1892.

5. Island opposite camp near junction, west side Lacloche Island, Murray, 1847.

6. West side of Lacloche Island, Lake Huron, Alex. Murray, 1847.
7. Islands between Lacloche Island and Manitoulin Island, R. Bell, 1859.
8. Fossils from the lower bed of the escarpment west of the lime-kiln near Hilton Village, St. Joseph Island, Lake Huron, Alex. Murray, August 15, 1860.
9. Fossils from the south-western Pallideau Island, opposite the Bruce Mines location, A. Murray, 14th September, 1867.
10. Island west of Grant Island.

UTICA FORMATION.

11. Along the shores of Shequenandod Bay and Islands, A. Murray, 1847.
12. Islands north of Maple Cape, Manitoulin Island, Lake Huron (collector and date not given on the specimens, but probably A. Murray, 1847). Zone of *Triarthrus Canadensis*, Smith.
13. Little Current, Manitoulin Island, Robert Bell, 1892.

LORRAINE OR RICHMOND FORMATIONS.

14. Summit of the Ordovician System—precise formation not ascertained. Manitoulin Gulf, Head transition beds.
15. Between Cape Crocker and Montresor (collector and date not given.)
16. Manitouwaning Bay, Lake Huron, in the upper part of the "Hudson River Group," R. Bell.
17. Ledge, top of shale, East Gore Bay, R. Bell, 1866.
18. Wekwemikong shore, Manitoulin Island, Lake Huron, R. Bell, 1892.
19. East side of Gore Bay, top of cliff, R. Bell, 1867. A commingling of Richmond and Lorraine formation species occurs in the collection. Both formations probably occur in the escarpment.
20. East side of Gore Bay, ledge of top shale, Manitoulin Island, Lake Huron, R. Bell, 1867.

LORRAINE FORMATION.

31. Griffiths Island, near light house, Alex. Murray, 1861.
22. Wekwemikong, Manitoulin Island, Lake Huron (collector and date not given but probably Alex. Murray).

RICHMOND FORMATION.

23. Establishment at Manitouwaning, Manitoulin Island, (collector and date not given).
24. Fossils from a point about 20 ft. high at N. E. point of Drummond Island, Lake Huron. Alex. Murray, Aug. 14, 1861.
25. Cape Smyth, Lake Huron, Robert Bell, 1859.
26. Cape Rich, Lake Huron, Robert Bell, 1859.
27. East side Manitouwaning Bay, near head, Robert Bell, 1865.
28. West side, Cape Robert, Manitoulin Island, Robert Bell, 1865.
28. Ka-ga-wong clearing, Manitoulin Island, Robert Bell, 1865.
- East side of West Bay, one mile from village, Manitoulin Island, Robert Bell.
29. East side of Gore Bay, Manitoulin Island, Robert Bell, 1867.
30. East side of Gore Bay, R. Bell, 1867, (Middle Terrace).
31. South side of Lacloche Island (collector and date not given).
32. Drummond Island, North Point.

CLINTON AND NIAGARA FORMATIONS.

33. Cliff over Cape Wingfield, about 138 feet over the lake, Manitoulin Island region, Lake Huron, A. Murray, July 18, 1861.
34. McLeod Harbour, two miles north of harbour, R. Bell, 1859.
35. Providence Bay, Manitoulin Island, Lake Huron, R. Bell, 1865.
- North-west corner of Ka-zoo-wong Lake, R. Bell, 1868.
36. South-east extremity, Elizabeth Bay, Robert Bell, 1865.
37. North-east extremity of South Bay, Manitoulin Island, Robert Bell, 1865.
38. North-west extremity, Manitoulin Island, R. Bell, 1865.
39. Ninety fossils from one mile S. S. East Head Gore Bay, Manitoulin Island, Robert Bell, 1866.
40. Top of cliff, East Gore Bay, R. Bell, 1866.
41. Wekwemikong Hill, Manitoulin Island, Robert Bell, Sept., 1892.
42. Lot 28, Concession VI, Township of Allan, Manitoulin Island, Lake Huron, Robert Bell, 1892.
43. South side of Manitoulin Island opposite the middle of Stone Lake, same as Lot 28, Con. VI., Township of Allan, Robert Bell, 1892.

44. Between South Baymouth and Blue Jay Creek, half way in the central portion of the area supposed to be Guelph in age, Grand Manitoulin Island, Ami, 1898.

45. Michael's Bay, west side, Manitoulin Island, south shore, Ami, 1898.

46. One and a quarter mile from where the post road crosses Blue Jay Creek, between Michael Bay and South Baymouth, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

47. Between Manitou and Blue Jay Creek, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

48. Ledges about two miles north of South Baymouth on the road to Michael Bay, Grand Manitoulin Island, Ami, 1898.

49. Old coral reef, six miles north of South Baymouth, west side of bay, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

50. Fossils from Cape Chin, Lake Huron, Alex. Murray, 1848.

51. Entrance to South Bay, Manitoulin Island, Robert Bell, 1865.

52. Barrier Island, Lake Huron, fossils from loose slabs of limestone. Pentamerus beds, (collector and date not given).

53. Cockburn Island, Lake Huron region.

54. Drummond Island, south-west end, A. Murray, 47, 1826.

55. Fairview Cove, Drummond Island, Lake Huron, Robert Bell, 1866. South side and west end of Drummond Lake, Lake Huron, Geol. Survey collection, determined by the late Mr. E. Billings.

56. East side of the village in the bight of West Bay, Manitoulin Island, R. Bell and H. G. Vennor.

To this horizon are assigned the gray shales, coral-bearing rocks, of the southern portion of the Island, and cream-coloured and gray fossiliferous limestones of the south shore of the Grand Manitoulin Island, near South Bay Mouth, Lake Huron, besides the gray limestones of Flower pots, Perseverance and Cove Islands.

57. West side of Thomas Bay, south shore of Manitoulin Island, Lake Huron, H. M. Ami and W. J. Stewart. July 29, 1898. (Zone of *Astrocerium venustum*, Hall.)

58. Irving Point, east side of South Bay Mouth, Grand Manitoulin Island, Lake Huron, H. M. Ami and W. J. Stewart, July 29, 1898.

59. Flowerpots Island, near the lighthouse, Lake Huron, H. M. Ami, 1898.

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60. Perseverance Island, Lake Huron, H. M. Ami, 1898.

61. Cove Island, near lighthouse, H. M. Ami, 1889.

Besides the above there are a large number of geological collections to which a precise geological horizon cannot be assigned without doubt, inasmuch as the evidence afforded by the materials examined was insufficient. Of these collections there are those which indicate the presence of summit beds of the Ordovician system, but which on account of the character of the material, cannot serve to determine whether the Lorraine or Richmond or both occurs. It is greatly to be desired that further material be obtained so as to complete the work.

Fossils from the island furthest south of the group off Point Pallideau, Lake Huron, as determined by the late Mr. Billings, indicate a horizon which is decidedly older than the Birdseye and Black-river formation and point to the existence at this locality of the Chazy fauna and formation. Additional material from the locality is much desired.

As regards the presence of the Guelph formation, the writer has not as yet recorded any occurrences of typical species of fossils of this formation in the collections examined from the Grand Manitoulin region.

Accompanying my report now in the hands of Dr. R. Bell on the determinations of the organic remains from various localities, in the Geological Survey Museum will be found a general review of the palaeontological evidence at hand in the writings of the following geologists and palaeontologists: J. J. Bigsby and Charles Stokes in 1824; of Charles Stokes again in 1849; Elkanah Billings in 1862, 1863 and 1866; H. Alleyne Nicholson in 1875; George Jennings Hinde in 1879; Arthur H. Foord in 1889; H. M. Ami in 1892; J. F. Whiteaves in 1896; H. M. Ami in 1899; and L. M. Lambe in 1900 and 1901.

It is extremely desirable that further collections be obtained from the Ordovician and Silurian succession of the Manitoulin Island district of Lake Huron, inasmuch as the sedimentation of that area is not only quite distinct from that of the Niagara and Toronto districts of the Ontario basin, but bears strong resemblance to the succession known and recorded in Indiana, Ohio and Kentucky to the south, as well as to that of the Island of Anticosti, in the valley of the St. Lawrence east.

Especially is this resemblance a striking one as regards the calcareous sediments of the Richmond formation, whose presence in the Grand Manitoulin island had not been hitherto detected.

B. Ontario and Quebec.

Faunal lists, together with the horizon they indicate, were prepared by me during the year 1902, from various localities in Central and Eastern Ontario and in a portion of the Province of Quebec along the Ottawa Valley.

From Belleville, Havelock, Douro, Dummer, Vensikle and Oak Lake settlements and other localities in Central Ontario, as well as from twenty-five localities in the Kingston district, such lists were prepared for Dr. A. E. Barlow's and Dr. R. W. Ells's reports respectively.

Work on
Pembroke
sheet.

Faunal lists were also prepared by me during the year from numerous collections and localities in connection with the Pembroke sheet or geological map of the Ottawa Valley about Pembroke in charge of Dr. R. W. Ells. The geological horizon indicated by the fossil remains entombed in the strata from which they were derived has also been added. The separation of the limestones of the Chazy, Birdseye and Black River, and of the Trenton formations, which occupy distinct positions in the succession of Ordovician strata of the Ottawa Valley was carefully effected and the value of the palæontological determinations and evidence thus obtained materially assisted in the mapping out of the various strata and formations in the district. To these were added lists previously determined by J. W. Salter, and E. Billings from various localities in the same district and published in scattered reports.

Collections
examined.

Some of the more important collections examined are from the following localities :—Paquette's Rapids, Fourth Chute of the Bonnechère, Clear Lake, Allumette Island, Westmeath, Fitzroy, Packenham, McNab, Stafford, Torbolton, Aylmer and Marlborough.

These faunal lists, together with the horizons they indicate, are intended to accompany Dr. Ells's report, in the form of an 'Appendix.'

Work on
Kingston
sheet.

Similar lists were prepared by me from the determinations made by myself in conjunction with Dr. R. W. Ells's work in the counties of Prince Edward, Lennox, Hastings, Addington, and also in the Kingston district during 1901. They include the following localities :—Kingston, Portsmouth, Rideau Station, Kingston Mills (Piloceras beds of Billings the zone of *Nanno aulema* Clarke), Kingston Quarries, Collins Bay Quarries, Westbrook Hill, Battersea (Vanluvin's mills of 1863 Report), Wolfe Island Quarries, Simcoe Island, Horse-shoe Island, Gildersleeve's Quarry, Picton, West Point near Sandbanks, Barriefield Hill, Deadman's Cove, Cherry Valley, Veesey Point, Ox

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- Point Quarries, opposite Mississauga Point and Belleville. Barytes Mine at Woodruff's, lots 16 and 17, Con. IV, also south half of the lot 16, Con. V and lot 15, Con. V, in the Township of Kingston, County of Frontenac.

Notes on collection of fossils, &c., made in 1886 by Mr. Eugene Coste and myself in Central Ontario were prepared by me in connection with Dr. A. E. Barlow's and Dr. Adams's work on the geology of that part of the province.

The species of fossil remains recognized in these collections were listed, the horizons which these predicated were also given, together with brief descriptions of the leading characters of the strata from which the fossils were derived. They include collections from a number of small outliers at Oak Lake, Round Lake, Breckenridge, Shenick and Vansickle. These notes were duly handed to Dr. A. E. Barlow and form a preliminary note on the fossils found in the Palaeozoic formations of Central Ontario, along the line of contact between them and the Archaean.

C. Nova Scotia.

Considerable progress was made in connection with the descriptions and classification of the faunas in the Silurian system as developed in Nova Scotia, with special reference to the Arisaig section, Antigonish Co. In this I was assisted by Mr. C. Frank King and a few drawings were made by Mr. O. E. Prudhomme. Inasmuch as it is not only important but necessary to have proper illustrations made of the various species represented in the departmental collections, the writer desires to emphasize the urgency of the needs of illustrating the various types which form a series quite unique for this continent both as regards their assemblage and characteristics.

Work on
Silurian
faunas.

D. Division of Ethnology and Archaeology.

Some time was also spent in entering and cataloguing the various additions to the ethnological collection of the museum made during the year. These collections are obtained by the members of the field staff during their explorations or from the general public interested in the discovery and preservation of archaeological records in Canada.

Accessions to
museum.

A list of the accessions made to the ethnological collections during the past year appears in another portion of this Summary Report.

E. Important accession to the Palaeontological collections.

An important collection of fossils of Cambrian age from Cape Breton was received in February, through Dr. G. F. Matthew of St. John,

Cape Breton
faunas.

New Brunswick, which serves to illustrate the various forms characterizing the geological formations of that portion of Nova Scotia. There is a striking resemblance between these faunas of Cape Breton and corresponding faunas in Wales. The following localities are represented :—Trout Brook, Mira River, Escasonié, McAdams shore, Barachois Station, I.C.R. cutting, Long Island, McInnis Brook, Gregwa Brook, Dugald Brook, McLeod Brook, Boisdale.

These form a valuable addition to our already extensive collection of Cambrian fossils. Owing to lack of space, however, it will be impossible to exhibit them until the already over-congested condition of the museum is relieved by the erection of a new building.

Mount
Stephen
fossils.

To Dr. G. F. Matthew the department is further indebted for determinations of species from the Cambrian of Mount Stephen, collected by myself in 1891.

Accessions to the palæontological collections of the department were recorded and many of the species represented determined in so far as the mode of preservation allowed.

Acknowledge-
ment.

The department is again under obligation to Prof. D. P. Penhallow of McGill University, Montreal, for identifications of fossil plants sent to him for determination. Several collections which were in the hands of Sir William Dawson, in Montreal, at the time of his death, have been determined by Prof. Penhallow and forwarded to the department.

F. Bibliography of Canadian Geology.

Work on
catalogue of
Geological
writings of
Canada.

A number of additions to the 'Catalogue of writings on the Geology and Paleontology of Canada' in course of preparation and completion were made by me during the year, together with the references to the current literature on the same subjects for the year 1901. Copies of the 'Bibliography of Canadian Geology and Paleontology for 1901' were prepared during the year, and a number of abstracts of the leading works on the paleontology of Canada were prepared for Dr. K. Keilhack's 'Geologisches Centralblatt' in Berlin, Germany, for the Transactions of the Royal Society of Canada, and also for the International Catalogue of Scientific Literature in connection with the Royal Society of England, for which latter, Prof. J. G. Adami of McGill University, is the recorder. The whole catalogue to date counts upwards of five thousand references to Canadian publications on geology and paleontology.

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G. Comparative studies while in Great Britain.

When in Europe during the months of June and July, comparative studies of the faunas of the Silurian of Great Britain were carried on by me in the British Museum, Natural History Department, and in the Museum of Practical Geology in connection with the Geological Survey of Great Britain, as well as in the Museums of Cambridge and Birmingham Universities, also at Ludlow in Herefordshire.

At the last-named place, collections of fossils were made illustrating the faunas of the Lower and Upper Ludlow, the Tilestone and Old Red Sandstone. This region constitutes the classic ground of Sir Roderick Murchison's 'Siluria,' and the materials obtained will be of special value in defining the limits of the various geological horizons occurring in Eastern Canada and comparing their faunas.

While in London, some time was spent with Dr. Henry Woodward, of the British Museum, in examining a collection of trilobites and other fossils from the Cambrian of Mount Stephen, in the Canadian Rocky mountains, recently made by Edward Whymper, Esq.

Work on
Mount
Stephen
trilobites.

H. Bibliography for 1902.

During the year 1902, a number of papers bearing upon the geology and palaeontology of Canada, including some of the official reports published by this department, were prepared by me and published either in full or in abstract, as follows:—

Bibliography.

Appendix. Preliminary lists of the organic remains occurring in the various geological formations comprised in the map of the Ottawa district, including formations in the provinces of Ontario and Quebec, along the Ottawa, pp. 49 G—77 G. Annual report, part G, Vol. XII. (Appendix to report by R. W. Ells) No. 741.

On *Belinurus Kiltorkensis*, Baily. American Geologist, Vol. 29, No. 3, p. 188. Minneapolis, March, 1902.

'The Great St. Lawrence-Champlain-Appalachian Fault of America and some of the geological problems connected with it.' Abstracts of Proc. Geological Society, London, No. 764. Series 1901-02, pp. 129-130, and 131 (discussion) London, Eng., June, 1902.

'Bibliography of Dr. George M. Dawson'. Canadian Record of Science, Vol. VIII, No. 8, pp. 503-516, Montreal, July, 1902. Separate issue, December 17, 1902.

'The Meso-Carboniferous age of the Union and Riversdale formations of Nova Scotia (Read before the Geological Society of America, Jan. 2, 1902) abstract. Science, Vol. XV, No. 368, p. 90, New York City, Jan. 17, 1902.

Notes on the Albany meeting of the Geological Society of America, held December, 1900. Canadian Record of Science, Vol. VIII, No. 7, pp. 471-477. Jan. 1902.

Annual Report of the Geological Section of the Ottawa Field-Naturalists' Club, for the year 1901-02. Addressed to the Council of the O. F. N. C. (Read Jan. 14, 1902) Ottawa Naturalist, Vol. XV, No. II, pp. 254-262, Feb. 5, 1902.

'The Union and Riversdale Formation in Nova Scotia.' (Discussion and correspondence.) Science N.S. Vol. XV, No. 375, p. 392. March, 7, 1902. New York City, N.Y., U.S.A.

The Cambrian age of the *Dictyonema* slates of Nova Scotia. Geological Magazine, Vol. 9. May, 1902, pp. 218-219, London, Eng.

Field-notes on the geology of the country about Chelsea, Que. Ottawa Field-Naturalists' Excursion, Chelsea, Sept. 6, 1902. Ottawa Naturalist, Vol. XVI, No. 7, pp. 149-151, October 6, 1902.

The Ordovician Succession in Eastern Ontario (Read before the Geological Society, America, Rochester, Dec. 31, 1901. Science, Vol. XV, No. 368. New York, Jan. 17, 1902, p. 82. abstract.) (With note on discussion by Bailey Willis, W. M. Davis and Hon. C. D. Walcott).

(I.) NOTES ON DRILLINGS OBTAINED IN SIX DIAMOND-DRILL BORE-HOLES
IN THE BED OF THE ST. LAWRENCE RIVER AT VICTORIA COVE,
SILLERY, EIGHT MILES ABOVE QUEBEC CITY, QUEBEC.

Through the kindness and courtesy of Mr. E. A. Hoare, engineer for the Quebec Bridge Co., Quebec, I had an opportunity afforded me of examining the drillings extracted from the six diamond-drill bore-holes which serve to indicate the character of the rock formations and materials occurring in the immediate vicinity of the abutments, anchor piers and main piers of the Quebec bridge now in the process of completion. The logs of the different borings were carefully preserved in boxes, and the following notes have been prepared by me, together with the sketch sections or illustrations accompanying them.

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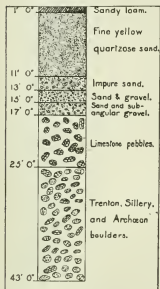
DESCRIPTIONS OF DRILLINGS.

North Side of the St. Lawrence River.

No. 1 Bore-hole. 43 feet. Anchor Pier, on centre line, 400 feet north of

No. 3 bore-hole. Shore above water level.

After penetrating the surface soil which consists of a sandy loam Bore-hole No. 1.



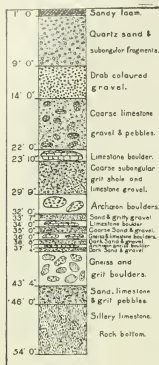
one foot in thickness in which grains of clear quartz abound, the drill traversed ten feet of fine yellow quartzose sand below which occurred two feet or more of rather impure sand, two feet more of sand and gravel underlaid by two additional feet of sand and fine subangular gravel. Eight feet were then traversed, in which limestone pebbles predominate, thus reaching a depth of twenty-five feet. Between twenty-five and forty-three feet depth, boulders of Trenton limestone associated with boulders of Archean crystalline rocks and pebbles of sandstones belonging to the Sillery grit formation occur. This bore-hole was not continued deeper.

Bore-hole No. 1 North Side.

No. II Bore-hole. Fifty feet east of the centre line.

Drillings consist first of about one foot of sandy loam, followed Bore-hole No. 2. downward by eight feet of quartzose sand rather coarser than the materials examined in bore-hole No. 1, together with a number of small subangular fragments of various kinds of rock and shale. Below this the drillings consist of five feet of a fine, well mixed, drab-coloured gravel underlaid by eight feet of coarse limestone gravel not unlike that met at the twenty-five feet depth in bore-hole No. 1. The next twenty-two inches were marked by the presence of a boulder of fossiliferous limestone underlaid by five feet and eleven inches of coarse and well mixed subangular pebbles of Sillery grit, Paleozoic limestone, shale, &c. In the next two feet three inches, a boulder of a dark crystalline Archean basic rock occurs, probably dyke material, with garnet, &c., underlaid by one foot seven inches of coarse brownish gray quartzose sand associated with grains of felspar and grits. A

lime-stone boulder was met in the next five inches at a depth of thirty-four feet below which sand similar to that overlying the boulders



Bore-hole No. 2, North Side.

north side of the river at Victoria Cove, Sillery.

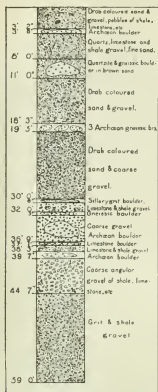
of limestone just described above, occurred to a depth of one foot, underlaid by two boulders, one, consisting of sedimentary or Palæozoic limestones, the other, an Archæan gneiss boulder. Eight inches of a dark-coloured, quartzose sand holding fragments of gneiss, the grains of both being subangular, are underlaid by a boulder of Archæan gneiss five inches in thickness, below which three inches of dark coloured sand occurred similar to that above the last mentioned boulder. Six feet were then traversed marked by the presence of boulders, of gray gneisses of Archæan age, and others of Sillery grit, underlaid by some eight inches of dark sand similar to that just described, in which were imbedded pebbles of Sillery grit, and limestone of Trenton or Black River age. The next ten feet, reaching a depth of fifty-four feet, were drilled in solid rock of typical Sillery grit, similar to that which occurs in the face of the escarpment on the

Bore-hole
No. 3.

No. III Bore-hole, 480 feet from base line, on the centre line; measurements taken from the river bed. Bed of River St. Lawrence.

Drillings at this point consist of three feet two inches of drab coloured sand and gravel in which quartz grains predominate and fragments of felspar, limestone, arenaceous shale (resembling shales of the Lorraine formation) associated with pebbles of Archæan and Trenton (Ordovician) age, are underlaid by a boulder of Archæan rock eight inches in thickness, below which are four feet four inches of angular fragments of quartz, limestones, shales, rather free from sand and well washed and preserved. The next three feet consisted of a white quartzite and biotite (gneiss or coarsely crystalline pegmatite) boulder imbedded in a rusty, chocolate coloured sand followed downwards by seven feet three inches of drab-coloured mixed fine and coarse

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Bore-hole No. 3, North Side.

mass :—

gravel below which were struck boulders of Archæan rocks consisting of light pinkish gray micaceous and hornblende as well as biotite gneiss reaching to a depth of nineteen feet five inches. Similar gravel to that just described above the boulders of Archæan rocks then characterize the drillings for the next ten feet seven inches down to a depth of thirty feet where a six inch boulder of Sillery grit was traversed by the drill. The next eighteen inches were characterized by a mixed gravel of limestone and shale fragments whose average size was about one centimetre across, below which, according to the engineer, 'a piece of a boulder was picked up with the two-and-a-half inch pipe' measuring three inches across which consists of a pinkish Archæan gneiss. Four feet six inches of coarse, mixed, angular gravel with boulders of Archæan rock then follow under which occurred a boulder of fossiliferous limestone of typical Trenton age as may be inferred from the following lists of fossil remains recognized in its

Fossils.

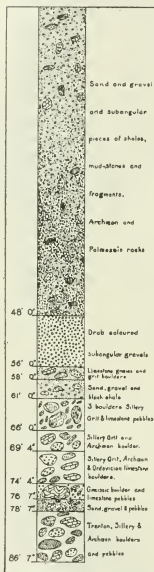
1. *Orthis (Dalmanella) testudinaria*, Dalman.
2. *Leptæna (Plectambonites) sericea*, Sowerby.
3. *Rhynchotrema inequivalvis*, Castelnau.
4. *Pachydictya*, sp.
5. *Monticuliporoid*, indt.
6. *Trilobite* fragment, too imperfect for identification.

For one foot two inches below this Trenton boulder, similar gravel to that above the boulder occurred, followed downward by a boulder of Archæan crystalline rock to a depth of sixteen inches deeper, below which again, similar gravel was struck to a depth of forty-four feet seven inches. In the next fourteen feet five inches, the drillings gave a gravel of grit and shales. At the depth of fifty-four feet "the tube broke" and the bore-hole was abandoned.

*South Side of the St. Lawrence River.*Bore-hole
No. 4.

No. IV Bore-hole. Bed of river.

The drillings which were examined as representing the first forty-



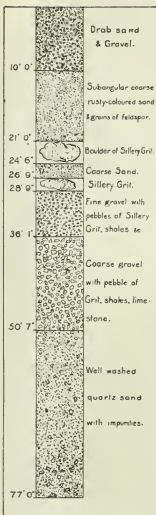
eight feet of the material obtained in this bore-hole consisted of small angular pieces of Archaean and Palaeozoic rocks together with water-worn and well rounded and subangular pebbles of the same rock and gray shale or siliceous mudstone. These are followed downward for eight feet by drab-coloured and subangular gravel. Then two feet of somewhat angular gravel with rounded blocks of limestone and boulders of pinkish gneiss with Sillery grit were traversed. The next three feet showed the presence of a sand or gravel with drab and rather dark coloured black shale with which were associated pebbles of Archaean gneissoid rocks and fragments of limestone, shales, &c., at times very angular. Three boulders of Sillery grit or sandstone follow with limestone pebbles in the next five feet of the drillings examined. These were underlaid by five feet four inches of similar rocks and pebbles, these in turn being underlaid by similar strata to a depth of seventy-six feet seven inches, where sand and gravel to a depth of two feet are then penetrated in which pebbles of Trenton limestone, of Archaean gneiss, of Sillery grit, black shale, &c., occur, followed downward by Trenton, Archaean and Sillery boulders to the bottom of the bore-hole at a depth of eighty-six feet seven inches where the drilling was abandoned.

Bore-hole, No. 4. South Side.

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No. V Bore-hole. Bed of river.

Drillings consist of drab coloured sand and gravel associated with Sillery grit materials to a depth of ten feet, followed by eleven feet of subangular and rather coarse sand with felspar fragments, in turn underlaid by a Sillery grit boulder three feet six inches in thickness below which, two feet three inches of a coarse sand, like that above, in which boulders of gneiss, limestone and grit occur.



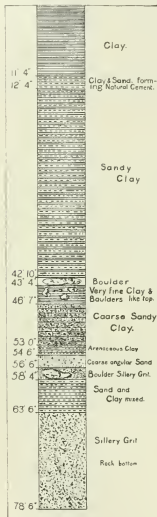
Bore-hole, No. 5. South Side.

One of the limestone boulders contained *Leptæna (Plectambonites) sericea*, Sowerby, indicating clearly the Trenton age of the mass. A typical Sillery grit boulder two feet thick was then struck, whilst the next seven feet are characterized by a mixed coarse and fine gravel with pebbles of clay slate, &c. This material prevails throughout the drillings downward to a depth of fifty feet seven inches whilst the next twenty-six feet five inches, are marked by the presence of well washed quartzose sand with grains of felspar, chlorite, &c., reaching to a depth of seventy-seven feet where the drill stopped.

Bore-hole
No. 6.

No. VI Bore-hole. Close to south cliff. South Anchor Pier, 200 ft. from foot of cliff.

Eleven feet four inches of a fine grained homogeneous bluish gray clay characterized the first series of drillings obtained. Below this bed



Bore-hole, No. 6. South Side.
six inch level, as given in the log accompanying the drillings.

of clay a layer one foot in thickness of a more or less arenaceous and calcareous clay occurred, which, when exposed to the air forms a rather strong natural cement, the grains adhering to one another very firmly, followed by some thirty feet three inches of a more or less pure though at times arenaceous clay. At a depth of forty-three feet four inches a boulder was met with about six inches in thickness, below which occurred three feet three inches of a whitish gray very fine clay, in which a Silly grit boulder was struck. This clay resembles the first or surface clay described in the drillings from this bore hole. Six feet five inches of a coarse sandy clay, mostly sand follow, below which is a similar stratum eighteen inches thick, forming a comparatively strong natural cement. Coarse angular sand follows two feet in thickness; then a Silly grit boulder twenty-two inches in diameter, below which are five feet two inches of a coarse rusty sand, continuing to a depth of sixty-three feet six inches. The drill then traversed the solid rock to a depth of fifteen feet. No sample of the rock traversed, however, was present in the drillings, but it is very likely, and most probable that the Silly grit rocks were struck at the depth of sixty-three feet six inches and penetrated to the seventy-eight feet

NOTE.

In connection with the building of the piers, abutments, &c., of the Quebec bridge, a number of interesting specimens were obtained and forwarded by Mr. M. P. Davis, contractor, through his manager, Mr. A. A. Stuart, to the department for examination, and as donations to the Museum. These include fossil plants obtained from excavations in the caissons both on the north and south slopes of the St. Lawrence river bed, Victoria Cove, Sillery, and samples of rock materials in which these were found imbedded at various depths from the surface. Besides these, a fine block of coarsely crystalline syenite or hornblendic granite employed in the construction of the piers and abutments from the quarries at Rivière à Pierre was also presented by Mr. Davis to the National Museum which serves to illustrate admirably the various characters of this building material so excellent for heavy masonry. Of this rock, Mr. Davis informs me that a single block was quarried which contained not less than 1,900 cubic yards, even and homogeneous in structure throughout. This single block thus weighed no less than 9,069,840 lbs., equivalent to 4,535 tons. The rock is of a light pinkish gray colour, quite pleasing to the eye, and takes a high polish, dresses and cuts well, constituting in a marked degree a highly desirable rock for heavy works and foundations.

Interesting
specimens
discovered.

Building
stone.

GEOLOGY OF THE SITE OF THE QUEBEC BRIDGE.

Early in October, with a view of determining the rock materials and geological formations upon which the abutments, anchor piers and main piers of the Quebec bridge rested, the Engineer in Chief and Deputy Minister of Railways and Canals presented a request that I should make a report upon the same. The result of the examination made by me from during field-work of 1901, of the drillings obtained from the diamond drill bore-holes, along the shore and in the bed of the St. Lawrence river at Victoria Cove, Sillery, eight miles above Quebec city, were verified and a report prepared, which has been transmitted to the Department of Railways and Canals and a duplicate copy of the same was deposited with the Acting director of this department, and reads as follows :—

PRELIMINARY REPORT ON THE GEOLOGICAL FORMATIONS IN THE
VICINITY OF THE QUEBEC BRIDGE PIERS AND ABUTMENTS,
VICTORIA COVE, SILLERY, QUE.

From the examination made of the materials obtained from within the caisson of the south main pier of the Quebec bridge, as well as of

the geological formations along the north and south shores of the St. Lawrence river at Victoria Cove, Sillery, Que., I am led to conclude that there are at least three distinct geological formations upon which the abutments, anchor piers and the north and south main piers rest, in the following ascending order of succession and of age :—

- I. The Sillery grit formation.
- II. The boulder clay or glacial drift formation.
- III. The later Pleistocene formation.

THE ABUTMENTS.

The abutments of the Quebec bridge, both on the north and south shores of the St. Lawrence river, rest directly upon the Sillery grit formation.

This Sillery grit formation consists for the most part of greenish drab-weathering and greenish-gray sandstones or coarse grits frequently assuming the character of fine conglomerates with white quartz pebbles at time the size of peas.

These sandstones are sometimes slightly micaceous, and occasionally hold scales of green and black shale, and a few spangles of graphite. They are often calcareous. They usually present massive beds, and at Sillery, the type locality, many of the layers are quarried for building purposes, the stone being used largely in Quebec city. When broken, the rock presents a sharp, cutting edge and fracture, the grains of material composing the rock being strongly cemented together.

THE ANCHOR PIERS.

The north anchor pier rests directly upon the Sillery grit formation.

The south anchor pier rests in the upper strata of the later Pleistocene or boulder sand formation, which at this point consists for the most part of fine clay and sand filling the interstices of rounded, water-worn and sub-angular boulders of Archean and Paleozoic formations, such as are seen strewn on the beach at low water, held in a matrix of stratified and well washed sand. The Archean boulders are as varied in composition, comprising as the rocks of that primitive series the Laurentian and Huronian systems as they are developed in the province of Quebec, including many eruptives.

THE MAIN PIERS.

The materials obtained from within the caisson of the south main pier indicate the presence of both 'the boulder clay or glacial clay' formation, and the 'sand and gravel formation' or later drift.

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The boulder clay or glacial drift formation occupies by far the greater portion of the area upon which the south main pier rests.

This 'boulder clay' is the characteristic 'till' or glacial clay of geologists, the 'hard-pan' of Canadian and other American engineers. It was deposited here at a remote period during the Glacial Epoch of geologists.

This formation consists of an indurated, compact, tough and unstratified rock-mass, composed of rounded, angular and sub-angular boulders and pebbles of Laurentian and Archaean gneisses and quartzites, associated with numerous boulders and pebbles of typical Sillery grit, sandstones and shales (of which materials the Sillery formation is composed), besides well-scored and striated or glaciated pebbles of limestone derived from the Trenton and Black River limestone formations of the north shore of the St. Lawrence, all cemented by an argillaceous paste, and held compactly together.

The materials, however, that were obtained from the two most westerly compartments within the caisson, consist of the 'boulder sand and gravel formation.' Rounded and sub-angular boulders and pebbles of Sillery grit and sandstones, of limestone, quartzite, gneisses and various other materials (not differing materially in character and composition from the boulders and pebbles constituting the boulder clay formation), are held in a matrix of sand, which, upon examination, appears to consist of well washed and fine grains of quartz, with occasional grains of hornblende and other impurities.

This sand and gravel formation is of later date than the 'boulder clay' or glacial drift formation, and was no doubt derived from the same, and is a stratified deposit.

THE NORTH MAIN PIER.

The north main pier rests upon the sand and gravel formation. From the materials obtained from within the caisson of this pier, it is evident that the boulders of gneiss, granite, quartzites and limestone, &c., which constitute this formation, have their interstices filled with sand and gravel, and that the whole is of sedimentary origin, of later date than the 'boulder clay or glacial clay' formation, and probably derived from it for the most part, being deposited as modified and stratified drift.

(Signed) H. M. AML

Geological Survey of Canada,
Quebec, Que., October 10, 1902.

2-3 EDWARD VII., A. 1903

The following communications from the Deputy Minister of Railways and Canals and from the Secretary-Treasurer of the Quebec Bridge Company, have been received in the department :—

I.

DEPARTMENT OF RAILWAYS AND CANALS.
OFFICE OF THE DEPUTY MINISTER AND CHIEF ENGINEER,
OTTAWA, ONT., October 10, 1902.

My dear Dr. AMI,

I have to acknowledge the receipt of your most able and interesting report on the geological features of the site and vicinity of the railway bridge in course of construction over the St. Lawrence near Quebec.

The information you have been good enough to supply me with, is precisely what I required, and I shall not be under the necessity of availing myself of your kind offer to supplement your report with further details.

Please accept my thanks.

I remain, dear Dr. Ami,

Yours sincerely and obliged,

(Signed) COLLINGWOOD SCHREIBER,
Chief Engineer.

II.

Dr. H. M. AMI, M.A., D.Sc., F.G.S.,
Commission géologique du Canada,
Ottawa.

Cher monsieur,—J'ai en effet reçu, hier du Département des Chemins de Fer, copie de votre excellent rapport sur les formations géologiques des excavations du pont de Québec, et vous remercie infiniment pour la part que vous avez prise à cet envoi.

Votre bien dévoué,

(Signé) ULRIC BARTHE,
Secrétaire-trésorier.

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Geological Survey of Canada

ROBERT BELL, Sc.D. (Geology) LL.D., M.D., F.R.S., ACTING DIRECTOR

1902.

Sketch Plan of GASPE OIL-FIELDS

— Showing —
LOCATION OF WELLS

*Illustrated Report by
R. WELLS, LL.D.
1902*

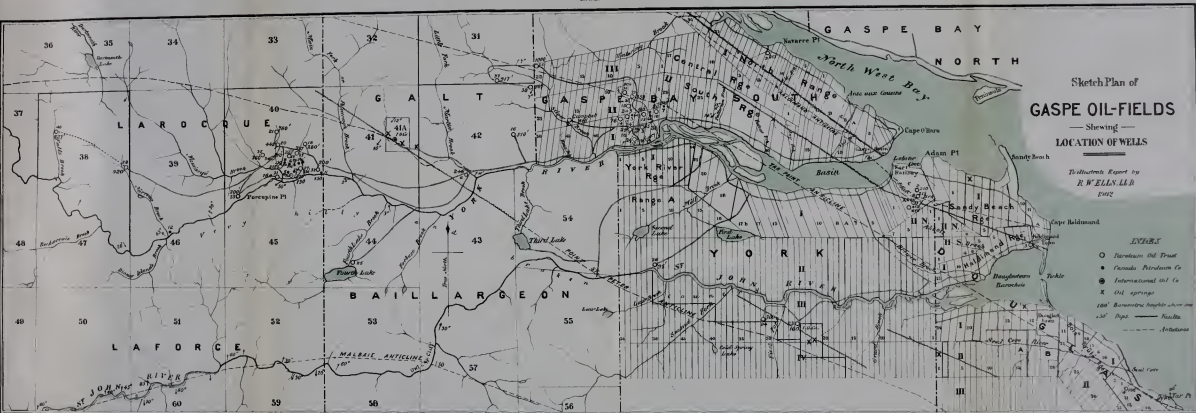
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- ⊙ International Oil Co.
- x Oil springs
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- 50' Dips ——— Faults
- Anticlines

To accompany Part A, Annual Report No. 17

No 802
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Oceans
Locations of wells and towns from plans supplied
by the Petroleum Oil Company



Drawn: Air photo lithography by F. Perrin, C. E.

GENERAL REPORT ON THE WORK OF 1902.

(Dr. R. W. Ellis.)

The office-work during the winter of 1901-2, comprised a rough Office work 1901-1902.
 compilation of the notes and surveys made in the Kingston district, chiefly by my assistant Dr. R. Hugh Ellis, B.A., and the preparation of the reports and geological maps pertaining to the Ottawa river area, west of Ottawa city, and comprised in map-sheets Nos. 119 and 122.

In May, 1902, a few days were spent in company with Dr. R. Chalmers, in an examination of certain points connected with the work of the late Mr. N. J. Giroux, formerly of this department, in the county of Glengarry, Ont. On June 10, I left Ottawa for Prince Edward Island, to examine the geological conditions in that province, relative to proposed borings for coal. This investigation extended from June 11 to July 17. The report on this examination is appended. Work in the summer of 1902.

At the close of this work, I proceeded to Gaspé basin to examine the structure of the Gaspé oil-field where boring operations, looking to the finding of oil in paying quantities, have been carried on continuously since 1889, by several companies. The principal work has been done by the Petroleum Oil Trust, Ltd. of London, Eng., by the Canada Petroleum Co. of Manchester, Eng., and by the International Oil Co. of St. Paul, Minn. Every facility for a thorough investigation of the district was afforded me, as well as an examination of all logs of borings, pumping output, records, etc., connected with the operations of the several companies, copies of all which were obtained. All the localities where wells have been sunk were visited, and a copy of the office plan of the Petroleum Oil Trust was made, on which the sites of all borings are indicated. Attention was paid to the geological structure of the basin in which the oil occurs, and the présence of several important lines of faulting was determined. These evidently traverse the area from north-west to south-east and are sometimes found closely associated with the several lines of anticline in the district. A report on the work has been prepared, showing the nature of the work already done and the output of the several wells from the commencement of boring operations, which is also herewith submitted. The Gaspé oil-field.

At the close of my work in Gaspé I returned to New Brunswick on Aug. 12, and in company with Mr. H. S. Poole of Halifax, visited some points of geological interest relative to our work in the south-eastern portion of the province. In this connection we examined the works of the Intercolonial Copper Co. near Dorchester, Work in New Brunswick.

and the oil wells of the New Brunswick Petroleum Co. near Memramcook and in the township of Hillsborough. Several sections were made of some of the divisions of the Lower Carboniferous formation, and some time was spent in studying the rocks of the Upper Carboniferous formation as developed about Bay Verte and in the Tormentine peninsula, in order to, if possible, obtain certain data with regard to the thickness of that formation as seen on Prince Edward island.

Kingston
area.

I returned to Ottawa on Aug. 26, and, after a week spent in the office, proceeded in company with Dr. Whiteaves, to the Kingston district in order to complete some details of work left over from the previous season. In this connection several localities of special interest were visited, as possibly affording characteristic fossils for determining doubtful points of structure in this area, and several good

Albert shales.

collections were obtained. We returned to Ottawa on Sept. 11 and on the 24th I again proceeded to New Brunswick, where, in company with Mr. Poole, an investigation was made of the Albert shale deposits found in Albert and Westmoreland counties, with a view to ascertain their value as a possible source of supply for oil by distillation. The report on this work is also submitted. I returned to Ottawa on Oct. 4.

Work by Dr.
Hugh Ellis.

In connection with the work on the Kingston sheet my assistant Dr. R. Hugh Ellis proceeded to that area from Gaspé on July 28. Surveys were carried on till Sept. 23, and these have been plotted ready for compilation. The area in which these were chiefly made is bounded on the east by the line of Hastings county and on the west by the line of the Kingston map-sheet, No. 112, which extends northerly from the Bay of Quinte, at a point about five miles west of the city of Belleville, through Madoc into the townships of Elzevir and Grimsthorpe. These surveys connected the work of the last season with that done in 1884 by Mr. E. Coste in the Marmora and Madoc district, and with that done by myself in 1896 in the townships of Clarendon, Barrie and Anglesea.

THE OIL FIELDS OF GASPE.

Dr. R. W. Ellis.

Early work
in Gaspé.

The several reports on the rocks of eastern Gaspé in which area the oil fields of that district are located, date back to the year 1844. The examination of this area was first made on behalf of the Geological Survey by Sir W. E. Logan the director, and by his assistant, Mr. A. Murray. In the reports for that year mention is made of the occur-

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rence of oil springs at several places in the district traversed by the lower portion of the Dartmouth, the York and the Douglastown rivers.

The section published by Sir William Logan of the strata seen along the shores of Gaspé bay and basin gives a very fair description of the rock formations which occupy the eastern portion of the peninsula. They consist largely of grayish sandstones, interstratified with grayish and sometimes reddish or brown shales, and the whole thickness given for the rocks of the series, which are of Devonian age, is about 7,000 feet. Beneath these rocks is a series of limestones which have a thickness estimated at 2,000 feet. These contain fossils in their upper portion which indicate a passage between the Devonian and Silurian systems.

The geological aspect of all these formations has already been very fully discussed in the preceding reports of this department, so that it will not here be necessary to allude further to this aspect of the question.

The cause of the investigation leading to the following report was the determination of the problem as to the economic occurrence of oil in this district. For some forty years investigations tending in this direction have been in progress by various companies, and several reports on the industry have been written. The early operations by boring were without practical result, but about 13 years ago renewed attempts were made to thoroughly explore the area. In this work, which is still being prosecuted, a large amount of money has been spent, largely in boring operations, and an amount of capital expended reported at over a million of dollars. Much of this work was done by the Petroleum Oil Trust with headquarters in London, England, and later by the Canadian Petroleum Co., with headquarters in Manchester. Other borings were made by the International Oil Co., of Minneapolis, and in all some 52 wells have been sunk, the depths in some cases reaching 3,700 feet.

Of these thirty-nine wells have been put down by the Petroleum Oil Co., twelve were sunk by the Canadian Petroleum Co., one by the International, and two others representing the borings of the early days were sunk, one at the summit of the ridge near Sandy Beach, the other inland about seven miles above Gaspé basin near the oil spring on Silver brook.

Comparisons have been made from time to time between the areas in Gaspé and those of the oil regions in Pennsylvania, and the state-

Devonian
rock section.

History of oil
investigation.

Wells sunk.

Comparison
with rocks of
Pennsylvania.

ment has been repeatedly made that the localities are geologically similar and the conditions for oil production practically the same. In so far as the geological horizons are concerned there may be some truth in these statements, since the oil territory in both cases is regarded as being in Devonian rocks. Otherwise the comparison fails in some important respects, as will be presently pointed out.

Early views as to the Gaspé oil basin.

Reference is made in the prospectus of the company (Petroleum Oil Trust) to opinions expressed nearly forty years ago by such eminent authorities as Sir W. E. Logan, Dr. T. Sterry Hunt, Dr. Robert Bell and others. In so far as any direct expression of opinion from these reports is concerned it is difficult to find anywhere any pronounced statement that the territory is eminently oil-producing. In point of fact no such opinion could then have been well put forward, for with the exception of the occurrence of small oil shows in the form of springs, and the fact that certain shale bands were of a bituminous nature, nothing further was then known. In those early days also neither the nature of oil-bearing rocks nor the conditions which govern the occurrence of oil in profitable quantities, were so clearly understood as at the present day, so that the favourable notices thus quoted must be taken with a great deal of reserve.

Unfavourable conditions for oil.

The conditions governing the present occurrence of oil in all recognized oil-fields to-day show that the strata as a rule must lie in a nearly horizontal attitude, or affected by slight undulations, the amount of dip rarely exceeding two or three degrees. Such are the conditions seen in the oil fields of western Canada (Ontario), in the eastern and central states, and in the oil fields of Colorado, where however the geological horizon belongs to a much more recent date, viz., to the Cretaceous system. In no case has oil in paying quantities been found in America in rocks which are much tilted and broken, though indications of oil are quite common under such conditions and even small quantities are found on boring.

Anticlines,

The area in which boring operations have been carried on in Gaspé extends in a north-westerly direction from Seal Cove, on the south side of Gaspé bay, to Falls brook, a branch of the York river on the north, in a direct line, thirty-three miles distant. The district is traversed by several lines of anticlinals which have a generally north-west course from the shore of the Gulf of St. Lawrence. Of these, the most northerly comes to the coast at Cape Haldimand, which is between Sandy Beach and the Douglastown barachois or mouth of the St. John river. This has been named the Haldimand anticline.

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Going south, the next line of anticline comes to the coast, near what is known as Tar point, on the south side of Gaspé bay and is known as the Tar point anticline. The third, known as the Point St. Peter anticline, comes to the sea at a point between Malbay and Gaspé Bay, while a fourth comes to the shore at or near Percé.

Good sections are afforded along the south side of Gaspé Bay from Point St. Peter north-west to Gaspé basin. Fairly good exposures are also seen along the several rivers which traverse the district from the west, including the Dartmouth, the York and the St. John or Douglastown.

The surface of the country, a short distance inland, is usually very rugged, with high ranges of hills, reaching in places, elevations of 1,200 to over 1,500 feet. The country itself, is generally densely wooded and except along the lower portion of the several rivers entirely unopened for settlement. Owing to forest covering, and the heavy deposits of drift, which are found over much of the area, good rock exposures are rarely met with off the lines of the principal streams. On many of the side streams also, the banks are composed of clay, gravel or other drift. The thickness of these drift deposits has been found in some of the boring locations to be nearly 100 feet.

An examination of the shore section shows that horizontal strata are rarely found. Generally the sandstones and shales are tilted at a comparatively high angle, in some places as much as 65 to 70 degrees. Faults are found at intervals not only along the shore section, but can be readily recognized on the rivers, and the strata are here in places at angles of 80 degrees.

The course of the several anticlines has been traced by numerous traverses as carefully as was possible. The underlying limestones have in many cases been assumed to represent these, especially where sandy strata are seen on either side. On the south side of the Dartmouth, the sandstones are inclined at angles as high as 80 to 90 degrees, and probably an overturn of the formation occurs between L'Anse à Cousin and the mouth of the Dartmouth. Faults are also observed at several points.

Of these faults, at least four well-defined ones occur on the shore section between Point St. Peter and the mouth of the Douglastown river. On the shore at the Narrows to the inner basin at Gaspé village, there is also a dislocation in connection with the anticline by which the beds are tilted at a high angle.

Inland this faulted character is observable at several points. Thus near the International Co's boring on section 41, north of the York river, a well-defined break is seen, by which the underlying limestone of Silurian age is brought sharply against the Devonian sandstone. At this break there are several oil springs, one of which is of large size, and these appear to owe their existence to this line of fracture. This line of fault can be traced south-east across the York and the St. John rivers, separating sharply the limestones from the sandstones and it is possibly continuous to the shore north of Malbay.

Oil springs in
fault lines.

It is very probable that most of the oil springs of the district are situated along lines of fracture, and in fact this feature is well seen at several points. The break which crosses the upper part of Gaspé basin at the village, is probably continuous to the north-west along the south side of the range of hills which occupy the area between the lower part of the York river, and the lower part of the Dartmouth, and a small oil-spring is found on this projected line of break, about three miles west of the village. From the high dips at the oil-spring south of Sandy beach where strata are inclined at an angle of 70 degrees, it is probable that this break continues eastward near the line of the Haldimand anticline, since there is also a spring near the shore on its course, just inside the head of the bar at the Douglstown barachois.

From the abrupt changes of dip seen along the St. John and York rivers at several points where the amount of inclination suddenly changes from 10 to 80 degrees, it would appear that these breaks are more frequent than has usually been supposed. In such a folded, inclined and faulted series of strata, therefore, one would scarcely expect to find highly favourable conditions for a productive oil-field, and this inference appears to be well sustained by the investigations of the last 12 years.

Conditions for
the occurrence
of oil.

In considering the question of the occurrence of oil in Gaspé in paying quantities, therefore, several conditions must be observed. First, the occurrence of true oil-bearing strata; 2nd, the favourable position or otherwise of such strata for the retention of oil if such ever existed in quantity; 3rd, the occurrence of faults and overturned rocks; 4th, the occurrence of anticlines along which the oil is supposed to occur.

As to the first proposition it may be said that while oil springs are found at several points throughout the area, the rocks of the formation, as seen along the numerous coast and river sections, do not display oil at any point with the exception of the small quantities found in portions

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of the dyke of intrusive rock which penetrates the Devonian sandstones near Tar Point. These sections furnish a good representation of the sandstones and shales of the formation from the bottom to the top. At the same time it must be admitted that oil in small quantity does exist in some portion of these sediments, since it has been found in several of the bore-holes.

In the second place the tilted and faulted character of the rocks throughout the greater part of the Devonian basin, both of eastern Gaspé and along such rivers as the Bonaventure and the two Cascapédias to the west, are unfavourable to the occurrence of oil in quantity, while the several faults which traverse the strata along which the oil springs presumably occur would serve to carry off along certain lines any small quantities of oil that might locally occur.

And, thirdly, the anticlines, instead of being in low, gently inclined strata are usually sharply defined: the inclinations of the opposing sides are often steep and the axes probably complicated by faults, as can be seen in several cases.

In the course of the recent examination of the area special attention was paid to the occurrence of such features as faults and anticlines in order to see if the theory usually put forth that the productive oils are found along anticlinal crowns was maintained in this area. As a result it may be stated that such application cannot be made for the Gaspé district. A number of deep bore-holes were sunk on or very near the line of axis of several of the anticlines without finding oil at all, or in but very small quantity, while some of the wells which were put down near the centre of the synclines are recorded as much more productive. In fact from the records of the numerous wells those bored in the central portion of the basins are practically the only ones that have yielded oil in appreciable quantity. Anticlinal theory.

The oils found are of two kinds, viz., a light amber oil which has been obtained from the upper or sandy portion of the formation, and a dark green heavier oil which was obtained usually from the lower or calcareous underlying rocks. It may here be stated that the supposed horizon of the oils would be found about the contact of the sandstones and limestones; and while in some wells there was a small showing at such places, in many cases this line was passed without any result as to finding the oil. Under such circumstances the difficulty of locating wells, with any certainty of finding oil in paying quantity, may be readily imagined. Kinds of oil found.

Acknowledgements. In my investigation of the district I may state that every facility was afforded me by the resident agent, Mr. Sutton LeBoutillier, and by the resident engineer, Mr. C. R. P. Hillary. I was also supplied with logs of all the wells from the commencement of boring operations, and in cases where the pumping plant was in place the wells were pumped for a time and the present daily capacity of each ascertained.

Records of Borings.

Boring record. My work was also greatly facilitated by the use of a plan in the company's office in which all the wells were located and which was placed at my disposal. The resident manager of the Canada Petroleum Co., Mr. Wheeler, also rendered me great assistance, giving me all possible information as to the logs of their wells and fixing their position on the plan of the district. To all these gentlemen our thanks are due for the courtesies extended.

The Sandy Beach wells. The earliest boring made in the district for oil was located on or near the crest of the Haldimand anticline about one mile south of the shore above Sandy Beach, at an elevation of 210 feet above sea level. This was in close proximity to the oil spring which occurs at that place.

This first boring was made in 1866 by Messrs. Conant and Hubbard, well drillers from Pennsylvania. Their log is given in the prospectus of the Petroleum Oil Trust, and may be briefly summarized thus:—

First well sunk 1866. Drift, about 25 feet. In this a small quantity of oil, probably from the adjacent spring, was found in the gravel.

In the boring proper a small vein of oil and gas was reported at 83 feet from which about one gallon of the former was obtained. At 238 feet a small showing of thin light oil with salt water was met, and traces also occurred at a depth of between 425 and 430 feet, not sufficient, however, for pumping. At 444 feet oil was again reported and again at 600 feet. At 684 feet the tools were lost, and after several unsuccessful attempts to recover these the boring was discontinued. A quantity of oil was obtained, by pumping which, it is said, in nine hours produced 25 to 30 barrels of oil, of 'a beautiful dark greenish colour.'

Work of the Petroleum Oil Trust. No further attempt to exploit this area was apparently made until the advent of the Petroleum Oil Trust. On November 19, 1889, boring was commenced and continued with many interruptions to January, 1891, when a total depth of 2,430 feet was reached. Much delay was caused by heavy flows of salt water at, 1,325 ft. and again at 1,700 ft., which

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required casing off. Oil was reported in small show at 2,048 ft. and again at 2,400 feet, and pumping was resorted to but no oil was found.

Three wells were sunk by the company at this place which are known as wells No. 2, 3 and 8.

Well No. 2 was commenced on May 1, 1890. The depth reached Well No. 2 on October 16, was 2,582 ft. Water was struck at several points, and three small shows of oil were reported at about 500 feet, at 965 feet, and again at the bottom, but all of no importance. The well was shot four times, viz, at the bottom, at 2,036 feet, at 1,200 feet and at 900 feet, but no oil was obtained, and no further work was done.

The log of well No. 3, located at the Douglastown beach near the head Well No. 3. of the Bar, is very incomplete. It was commenced apparently about October 14, 1890, and reached a depth of 2,225 feet. Salt water was found at 1,304 feet and no oil was reported.

Well No. 8 was begun on November 8, 1892. Salt water was Well No. 8. struck at 745 feet, at 936 feet, at 1,175 feet and at 1,450 feet, and was successfully cased off. The rig was burned down and subsequently rebuilt, but the difficulty found in sinking was such that the hole was soon after abandoned and no oil was recorded. At present there is no oil in any of these wells.

It may be said that all these four wells, Nos. 2, 3, 8 and that of 1866, are located within a very limited area. The rocks are highly inclined and there is probably a fault in this direction. The record of rocks passed through is very incomplete, except that they consist of grayish sandstones and shales with some purple or reddish bands, similar to the sediments seen in the coast section at Cape Haldimand. Being situated on the crown of the Haldimand anticlinal and in the immediate vicinity of one of the largest oil-springs in the district it was supposed that the locality was especially favourable as regards the finding of oil in paying quantity. The expectation however, was not realized. Rocks passed through.

Well No. 4 is situated on or near the Tar Point anticline. The Well No. 4 at locality is about 100 feet above sea level and about half a mile from the Tar cove. shore of Gaspé bay.

The log is incomplete as regards details. The rocks passed through were all sandstones with beds of shale, such as are seen along the shore east of Seal Cove. The drilling is reported as good to a depth of 2,540 feet when hard rock was encountered, and in this it was continued to a total depth of 2,970 feet when the tools were stuck and

could not be recovered. A small show of oil was reported, though of no importance, at 2,215 feet, but there was nothing to warrant further investigation at this locality apparently, and no further attempts were made at this place.

Well No. 5,
west of Gaspé
village.

Well No. 5 is the first of a series bored in an area about 7 miles west of Gaspé village, on the north side of the York river. It is near the line of the main road up the river leading to Silver brook. The log is very incomplete and the date of boring is not stated except 1891-92. The total depth reached was 2,640 feet. At 1,850 feet a small show of oil was reported and at 2,360 feet a small show of green oil also. Limestone was struck at this depth and continued down to 2,458 feet; and on September 27, 1891, the tools were lost in the hole, and not recovered. No oil was found below 2,360 feet. In January, 1892, it is reported that four barrels were bailed out. The well was shot on October 25 of that year without any satisfactory result, only about two barrels being pumped on November 9. It was again shot on December 11, 1893, but gave no further results. This well evidently passed the contact between the sandstone and limestone, at which horizon it was supposed oil would be found. On December 23, 1893, this well is said to have pumped oil, after being shot, at the rate of 2 quarts per day, and the same amount on January 5 and 6, 1894. A small quantity in the water in stand-pipe about 25 feet from the top.

Wells No. 6
and 7.

Well No. 6 was located on the bank of a small brook about 12 miles west of Gaspé village, or $5\frac{1}{2}$ miles west of No. 5. It is in close proximity to a ridge of limestone which crosses the road a short distance west of the location, but though a depth of 3,640 feet was reached, this limestone was not found. It is probably near a line of fault which extends in a south-east direction from the International Co's. property situated about three miles north-west where this fault is well defined, the limestone being brought directly against the sandstone and the dip of the fault being to the south-west. The rocks in this boring are shales and sandstones and only a small show of oil of no importance was recorded at a depth of 2,950 feet. The hole was begun on January 25th, 1892, and work closed on October 22nd of the same year. Salt water was struck at 395 feet, at 440 feet and again at 590 and 690 feet, to which depth the well was cased.

Well No. 7 is in the same area as No. 5 and about half a mile west. It was commenced on October 18th, 1892, and finished on November 21st of the following year. The depth reached was 2,867 feet and the limestone was struck at 2,385 feet, at which point a small show of oil and salt water was struck. Oil was also found at a depth of 2,589

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feet and again at 2,650 feet. The boring in the limestone was very difficult as the rock is generally very hard and silicious. From the samples it appears to be a hard silicious dolomite. The well was shot with 200 quarts of nitro-glycerine at 2,589 feet on November 29th, and pumping was commenced on December 15th. Water only was pumped at first, but on December 16th, an amount of oil estimated at 20 barrels was obtained. The pumping log of this well is interesting. On December 19th it pumped about three barrels; on December 23rd an average of about a half a barrel per day. In 1894, January 5th and 6th, this well is said to have yielded at the rate of a half a barrel per day, and on February 14th the bottom hoop of the tank in which the oil was stored burst off and a quantity of oil, estimated at 200 barrels was lost.

Well No. 9 is the only one bored on the north side of the Haldi-mand anticline. It is situated about one-half mile south of the Dartmouth river and 4 miles west of Gaspé village. The hills to the south are high and composed of limestone, the strata in the vicinity are steeply inclined and near by are faulted and apparently overturned. The well was begun on March 7th, 1894, and reached a total depth of 2,719 feet. The boring continued in sandstone and shale the whole distance. Water was struck at depths of 495 and 560 feet, but no sign of oil was found. Well No. 9.

From the position of the limestone hill to the south of this locality it is evident that a heavy fault cuts across the area and brings the two sets of strata in contact at a high angle. The location of this boring was a very bad one. Heavy fault.

In the area in which wells Nos. 5 and 7, already described, are located, no less than 13 wells were bored. Of these nine were sunk by the P. O. T. and four by the C. P. Co. They are all situated in a space of about one square mile on the north side of the York river, as per plan, and are for the most part south of the Tar Point anticline, though wells Nos. 15 and 36 are situated near its crest.

Well No. 10 was commenced in January, 1895. It reached a depth of 1,400 feet, the rocks for the entire distance being sandstone with occasional bands of shale. Water and gas were struck at 775 feet and small shows of oil at 1,108 and 1,170 feet. On October 26 the well was shot with 160 quarts of nitro-glycerine at 1,400 feet. No oil was taken out and the well was abandoned on account of water and caving of the sides. This well was near the supposed line of the anticline. A small quantity of green oil now in stand-pipe. Wells No. 10 and 11.

Well No. 11 is situated about one mile west of the last and about half a mile south of the anticline. Work was started on 29th December, 1893, and the hole was bored to a depth of 2,957 feet, which was reached March 23th, 1895. Sandstone extended down to 2,080 feet, at which point the limestone was struck. At 2,220 feet, in the limestone, gas and oil were reported, and an explosion took place by which the rig was burned down on May 2nd, 1894. The rig was rebuilt on June 24th. Oil flowed and a supposed large quantity was lost during the night, estimated at some hundreds of barrels. The boring was resumed and a small show of oil was again reported on September 7th at a depth of 2,485 feet. The limestone continued to the bottom of the hole without finding any more oil. The rig was again burned on May 13th, 1895, and rebuilt. The well was shot twice in the following September without any beneficial result, and subsequent pumping in October yielded a very small quantity of oil. A little oil on surface of water in stand-pipes, about four feet from surface.

Wells No. 12
and 13.

Well No. 12 is located near the north bank of the York river and about one mile south of the line of the Tar Point anticline. It was commenced in January, 1894, and finished on May 4th at a depth of 3,002 feet. It passed through sandstones and shales for 2,550 feet when the limestone was first struck, and this rock continued to the bottom of the hole. A very small show of oil was reported at depths of 2,075 feet and at 2,837 feet. The well was plugged at 2,830 feet for shooting. It was not pumped and no oil was found worth recording. A very little oil now in stand-pipe on the water about ten feet from top.

Well No. 13 is located a short distance north of the main road and about half a mile south of the anticline. Drilling commenced on September 1st, 1894, and continued to December 26th, when a depth of 2,050 feet was reached. The limestone was not struck and no oil was found. At the bottom the well was overflowing with salt and sulphur water which rendered further drilling impossible. Now flowing salt water.

Wells No. 14
and 15.

Well No. 14 is situated three-quarters of a mile west of the last and about three-quarters of a mile south of the anticline. It was commenced May 4th, 1895, and reached a depth of 2,775 feet on February 13th, 1897, nearly two years being spent on the work. The limestone was struck at 2,265 feet on October 19th, 1895, and the subsequent drilling was very slow, the limestone being very hard. Neither oil, salt water or gas found in this hole, but there is a small quantity of green oil on the water in stand-pipe.

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Well No. 15 is situated about $\frac{1}{4}$ mile south of the anticline. It was commenced on April 1st, 1895, and reached a depth of 2,012 feet on August 17th, the limestone being struck at 1,880 feet. At this depth it is said that about 50 barrels oil were bailed out. Well torpedoed at bottom and fitted for pumping. Yielded continuously about 7 to 8 gallons oil for several months. In spring of 1901 gave about two gallons per day. All work discontinued and nothing done since. A small quantity of green oil on the water in stand-pipe, about six feet from surface.

Well No. 36 is the most northerly in this area. It is located about $\frac{1}{8}$ mile north of the anticline, the position of which can be readily seen on the road up the mountain, the elevation of the starting point being 804 above sea-level. Work was begun on July 9th, 1901, and continued to December 4th, to a depth of 1,950 feet. The limestone was struck at 1,780 feet, the rock above this being, apparently, for the most part sandstone. Salt water was struck at 1,065 feet, and was met with at intervals to the bottom. No trace of oil was found in this hole.

Of the four wells bored by the Canada Petroleum Co. at this place numbered 3, 7, 9 and 10, the following notes were furnished me by the resident manager, Mr. Wheeler. Wells of Canada Petroleum Co.

Well No. 3, started August 15th, 1899, finished November 11th, reached a depth of 2,240 feet. Limestone struck at 2,230 feet. No oil.

Well No. 7. Date of boring not given. Depth 2,063 feet. Limestone at 2,046 feet. Oil reported at 1,945 feet. Took out from 2 to 3 barrels only.

Well No. 9. Depth 2,226 feet. Limestone at 2,212 feet. No oil found, but water in large quantity at 1,132 feet.

Well No. 10. Depth 2,383 feet, limestone at 2,360 feet. No oil found in boring, but in July, 1901, a quantity reported at 3 barrels, was obtained, and there is a little at present in the stand-pipe.

Another group of wells is situated on block 40, on the north side of the York river, near the junction of the Mississippi branch. This group included about 23 wells, the of which are comprised in an area of about one square mile. Of these, the Canada Petroleum Co. put down seven. A tank for a pumping station was also erected at this place, and connected by a pipe-line eleven miles long, with a refinery which is located on the bank of the river, about seven miles west of the village of Gaspe' Basin, in the group of wells just described. Wells of the 2nd group.

Campbell
well and well
No. 16.

Several intermediate wells were located between these two principal areas, of which that known as Campbell's, on the bank of Silver brook, was one of the first bored. It was located near the oil spring which is described in Logan's report as occurring in that district. No log of this well exists, but apparently no oil was found in the boring, which is placed at some distance south of the line of the Tar Point anticline.

Well No. 16, bored by the Petroleum Oil Trust, is about two miles west of Silver brook, and about one mile north of the main road up the York river. It is near the foot of a high ridge which rises to the north. The elevation is 510 feet above sea-level. The boring commenced on January 26th, 1895, and ended August 17th of the same year. The depth reached was 2,995 feet, and the limestone was struck at 2,880 feet. Only one small show of oil was found at a depth of 2,664 feet. Not much salt water was met with, and no oil was taken out. This place should be about the middle of the syncline between the Tar Point and Point St. Peter anticlines.

Well No. 17.

The wells of the second group lie to the south side of the latter anticline. Of these, well No. 17 was commenced on March 30th, 1895, and finished on June 26th, 1897, over two years being occupied in the boring. The hole reached a depth of 2,550 feet, the limestone being struck at 2,000 feet. Great difficulty was experienced in boring the limestone, which caused the delay. In all, only one and a half barrels of oil was taken from this hole, though oil was reported at depths of 1,013, 1,045, 1,200 and 1,286 feet. The reported bailing of oil was from a depth of 2,348 feet.

Wells, No. 18
and 19.

Well No. 18 was begun on August 24th, 1895, and finished on June 9th, 1896, at a depth of 1,960 feet. The limestone was struck at 1,865 feet, the rocks to this depth being sandstones and shales. A very small show of oil was found at 990 feet, and at 1,095 feet. This well was shot with twenty-five quarts of nitro-glycerine, but no oil was found in the boring. There is now a small show at the top of the stand-pipe.

Well No. 19 is located about three-quarters of a mile north of the York river, at an elevation of 355 feet above sea-level. It was commenced on November 7th, 1895, and finished on April 16th, 1896, at a depth of 2,340 feet at the contact with the limestone, the boring being in sandstone and shale all the way. Salt water was struck at 700 feet and again at 1,500 feet. The first small show of oil was found at 1,185 feet, a second show at 1,792 feet, and a third at 2,050 feet. No oil was found at the contact with the limestone. On August 1st, after taking out about ten barrels of amber oil, the well was shot with 100 quarts of

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nitro-glycerine, at a depth of 2,040 feet. On August 5th, after cleaning, the well produced about one-half barrel of oil per day for a time, and on August 25th, it was tubed and connected with tank. It is reported to have yielded one-half a barrel of oil per day for a few days, which then reduced to ten gallons, and in 1902, (August) yields by pumping, from two to three gallons per day.

Well No. 20 is situated about half a mile north-west of the last, and nearer the anticline. The elevation at the surface is 442 feet. The boring commenced on January 1st, 1896, and continued to June 30th at a depth of 2,050 feet in sandstone, when a small vein of oil and gas was struck. It was afterwards continued to a depth of 2,173 feet in limestone. It was shot with 100 qts. of nitro-glycerine at 2,059 feet without beneficial results, only half a barrel of oil being bailed in 24 hours. On August 5th it was tubed and pumped, and gave about five gallons a day for a time, and in July, 1902, it yielded from half to one gallon per day. Salt water was struck in the boring at 595 feet. This oil seems to have been met near the contact of the sandstone and limestone.

Well No. 21 lies about half a mile north of No. 20, and near the axis of the anticline. The elevation is 780 feet. Boring began on April 24th, 1896, and ended on June 12th, 1897. The limestone contact was met at 1,555 feet where there was a strong smell of gas and a very small trace of oil which was of no importance. No salt water was reported, and the drilling in the limestone was very difficult. The boring reached a depth of 1,830 feet without any further showing of oil and the work was abandoned. The limestone throughout is reported as fine-grained and very hard. No oil was extracted.

Well No. 22 is located in the eastern area, north of group one, near the crest of the Tar Point anticline and at an elevation of 1,000 feet. This boring proceeded in sandstone and shale to a depth of 2,750 feet when the limestone was reached. It was then carried down to a total depth of 3,130 feet in the limestone. The boring began on April 1st, 1896, and ended on July 22nd, 1897. No oil was observed at the contact and the first small show was met at a depth of 2,945 feet, with water and gas. On March 20th, 1897, a large vein of gas and oil was reported at the contact with a white sand at a depth of 3,105 feet and strong brine was struck at 3,107 feet. A pumping plant was then installed and operated till June 19th. The pumping log shows some points of interest. Thus, on April 5th, a good show of oil was found in water. On the 22nd half a barrel of oil was taken out, and on the 23rd four barrels of oil. On the 26th three barrels of oil, and on the 29th the same amount. On the 30th only two barrels of oil were obtained,

and on May 3rd this was reduced to one barrel, on the 4th to half a barrel, on the 8th, it yielded one barrel and a half. On the 15th the oil lessened in quantity and was less than half a barrel per day. On the 28th it yielded one barrel of oil, on the 29th three barrels, on June 5th, two barrels, and on the 12th one and a half barrels. On the 16th only a pail of oil with water was obtained and drilling commenced again after pulling tubing. On July 13th more water was struck, and on the 22nd the well was abandoned. This well apparently tested the anticlinal axis better than any of the previous ones. The location was near the upper part of Silver brook.

Well No. 37. In the vicinity of the same anticline two other wells were put down at a later date, viz., Nos. 37 and 38. Of these No. 37 was situated near the axis of the anticline but a short distance on the south side. The elevation was 917 feet and the thickness of the drift was 73 feet. Bands of hard limestone were struck at 455 feet and continued down to a depth of 645 feet. Below this to the bottom of the hole, at a depth of 2,600 feet the rocks were all sandstone, which were calcareous for the last 200 feet. A small showing of green oil was reported at 2,218 feet, from which about two barrels were taken, but none was found below this point. The boring began on September 18th, 1901, and ended on March 15th, when the work was discontinued. The occurrence of the limestone in the upper part of this boring is interesting. Salt water was struck at 927 feet and 1,875 feet, and gas at 1,925 feet.

Well No. 38. Well No. 38 is located about one mile east of the last at an elevation of 887 feet, and also on the south side of the anticline not far from its crest. The boring began on November 20th, 1901, and ended on March 14th, 1902, at a depth of 2,089 feet. The boring was in sandstone throughout, but the rock was somewhat calcareous in the last 50 feet. A very small show of oil was reported at a depth of 2,030 feet, which was the only indication observed. Salt water was struck at 955 feet, and much trouble occurred from this cause at 2,000 feet, so much so that operations were suspended. No oil was taken from this well and the underlying limestone was apparently not reached.

Wells, No. 23 and 24. Two holes, Nos. 23 and 24, were put down on the south side of the St. John river about seven and eight miles west from the mouth. The drift in the first was heavy, amounting to 52 feet. Drilling began on Aug. 4th, 1896, and ended at a depth of 1,790 feet on May 26th, 1897. The sandstone continued down to a depth of 1,480 feet to the limestone. Heavy salt-water was struck at a depth of 1,670 feet, and the well was cased to 1,690 feet. Owing to the difficulty of penetrating

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the limestone boring was abandoned at 1,790 feet and no trace of oil was noted. The elevation of this well is 160 feet above sea-level.

Well No. 24 is about one mile west of the last. The elevation is 300 feet and it is a short distance north of a high ridge of limestone. It was commenced on January 10th, 1896, and work ended in May at a depth of 1,230 feet. The sandstone was very thin at this place and the rock was mostly a very hard limestone to the bottom. The hole having become crooked was abandoned on account of the difficulty in penetrating this rock. No trace of oil was observed in this boring, and it is possible that a line of fault running between these two holes, traverses the area in a south-east direction.

Well No. 25 is located at Fourth lake, about midway between the St. John and the York rivers, on block 44. It should be about the central portion of the area between the Point St. Peter and Malbay anticlines. The elevation of this hole was not taken, but is not far from 200 feet. The depth of the drift at this place was 63 feet. Work was commenced on December 2nd, 1895, but owing to difficulty in getting to bed rock, drilling did not commence till August 14th of the following year. It continued till July 10th, 1897, when a depth of 1,230 feet was reached. The log gave sandstone for 605 feet to limestone, which thence continued to the bottom. There was no show of oil in this boring.

Well No. 26, situated near the St. John river at an elevation of 96 feet, was begun on February 13th, and finished on September 29th, at a depth of 2,900 feet according to log, though samples of borings are on file to a depth of 2,978 feet. No oil was found in this hole. Sandstones and shales continued down to 2,200 feet to the limestone, and from this to the bottom the rock was, for the most part, limestone with occasional sandy layers. A little gas was struck at 1,700 feet, and also at 2,550 feet. The hole ended in sandstone and limestone according to the samples, but the log registered limestone only.

Well No. 27 is located in the second group of wells, north of York river. It was commenced on February 28th, 1897, and bored to a depth of 1,467 feet in sandstone with occasional bands of pebble conglomerate, the pebbles being mostly white quartz. At this depth a vein of oil and gas was struck in the conglomerate which is said to have flowed three times before being plugged. This oil was all lost. The well was subsequently carried down to a depth of 2,200 feet, and a considerable quantity of oil taken out and tanked. These tanks were burned in June, 1898, the quantity of oil destroyed being estimated at several hundred barrels. After deepening the hole no other large

quantity of oil was found though the limestone was reached, and the well is now pumping (July, 1902) about two gallons per day. The location is about one mile south of the supposed crest of the Point St. Peter anticline, and the elevation is 230 feet.

Well No. 28. Well No. 28 is situated on the line between blocks 38 and 39, near a small stream which flows into the York river. It is about five miles west of the last, and about two and a half miles south of the anticlinal. It was begun on June 19th, 1897, and the rig burned down on July 22nd. This was rebuilt, and drilling began again in September, and continued till June 7th, 1898, to a depth of 3,525 feet. The hole was in sandstone and shale for the entire distance, the limestone not being reached. No oil was found, but salt water was struck at 1,100 feet, which is now flowing from the pipe. The elevation of this hole is 920 feet.

Well No. 29. Well No. 29 is situated in the second group of wells a short distance north of the York river at an elevation of 130 feet. It was commenced on November 27th, 1897: the drift was $61\frac{1}{2}$ feet deep. It reached a depth of 2,600 feet in October. A little gas and oil was reported at 2,180 feet, and salt water at 840 feet, at 1,209 feet, at 1,380 feet and at 1,450 feet. The limestone was not reached and the hole was abandoned in shale and sandstone. At this well the central collecting tank for the area is located, and from this point the pipeline of eleven miles extends down to the refinery at the first group of wells, about seven miles west of Gaspé village. A pumping station was also erected, and in the tank there is at present a quantity of amber oil, estimated at from 200 to 250 barrels.

Well No. 30. Well No. 30, is located one and a quarter miles north-west of the last, near a small brook about one mile north of the York river, the elevation being 215 feet. It was begun on June 24th, 1898, and ended January 20th, 1899, at a depth of 1,580 feet. No oil or gas was found in this hole, which was sunk in sandstone for the entire distance, but salt water was very abundant and was struck at 860 feet, at 930 feet, at 1,022 feet, at 1,075 feet, at 1,150 feet, at 1,210 feet, at 1,450 feet and 1,480 feet, the water at last being too heavy to continue operations.

Well No. 31. Well No. 31 is one mile south of the last and on the bank of the York river at the mouth of the same small brook as the last. The elevation is 164 feet, and the boring was commenced on April 4th, 1898, and continued till April 30th 1899, to a depth of 2,815 feet. The contact with the limestone was found at 2,450 feet, and there was a small showing of oil at 1,700 feet. The well was reported as giving

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about one barrel of oil per day for a short time, and the total output is given at about 23 barrels.

Well No. 32 is the most easterly of this group. It is situated near the bank of the York river at an elevation of 200 feet. Boring began in January, 1899 and the hole was carried down in sandstone and shale to a depth of 1,825 feet to the limestone in which the boring continued to a total depth of 1925 feet, on June 13th. A little gas and oil was found at the contact, and it is reported to have yielded about ten gallons of oil per day for a time. In July, 1902, it pumped from 5 to 6 gallons a day, but irregularly. The pumping log of this well gives a total yield to Aug. 9th, 1902, of 1,745 gallons.

Well No. 33 is situated $2\frac{1}{2}$ miles further up the river than the last and on the bank of the stream. The elevation is 200 feet. Work began on May 8th, 1899, and ended on Aug. 26th, 1901. No oil was found in this hole and the limestone was not reached, the rock being sandstone and shale throughout. The well is now discharging salt water, which with gas was struck at several points, and the total depth reached was 2,607 feet.

Well No. 34 is located near the centre of the second group of wells at an elevation of 310 feet. It was commenced on June 25th, 1900, and ended Oct. 6th, at a depth of 1,677 feet. No limestone was reached. A small quantity of oil and salt water was struck at 1,600 ft. It pumped half a barrel a day for some time, the record of the pumping log giving a total yield to May 24th, 1902, of 1,744 gallons. Since that date to Aug. 9th, the output has been only salt water.

Well No. 35 is about $1\frac{1}{4}$ miles north-west of the last. The elevation is 360 feet, and it was commenced in May, 1901, and continued to a depth of 1,810 feet, on the 17th August. Limestone was struck at 1,800 feet, but no show of oil was found. The limestone was so hard that the breaking of the tools prevented further work.

Well No. 36 is the most northerly of the wells in group one near Gaspé Basin. It is situated near the crest of the Tar Point anticline at an elevation of 804 feet, and is probably about one-eighth of a mile north of the supposed axis. Work began on July 9th, 1901, and continued till Dec. 4th, to a depth of 1,950 feet. The probable contact of the limestone was reached between 1,780 and 1,825 feet, as some sandy layers were intersatified in this portion. No oil was found in the boring, but salt water was struck at 1,065 feet, and again at 1,225 feet. The limestone in the lower portion also appeared to have interstratified sandy layers.

Well No. 40. Well No. 40 is the most westerly hole bored. It is located on Fall brook, a branch of the York from the north, in the west part of block 38. Its elevation is 827 feet, and it is supposed to be a short distance south of the St. Peter anticline. The log of this well showed sandstones all the way to a depth of 2,305 feet.

Well No. 39 not bored. Well No. 39 is located on the line of the Tar Point anticline, north of the wells of group one, but though the rig is in place it has not yet been bored, since the results of the surrounding wells were so unsatisfactory as, in the opinion of the resident engineer, not to warrant the expense.

Wells of the Canada Petroleum Co. In addition to the wells of the Petroleum Oil Trust just described, a number of other wells was bored by the Canada Petroleum Co., in the area included in groups one and two. Of these the four located in group one have already been noticed in preceding pages. Of the second group seven were put down on the north side of the York river, including Nos. 1, 2, 4, 5, 6, 8 and 11, while a 12th well was located on the bank of the York at the mouth of a small brook on the north side about five miles further up the river. With the exception of the last these are all located on what is known as block 40.

Well, No. 1 and 2. Of these wells, No. 1 was started on July 6, 1899, and finished on Sept. 22nd, at a depth of 1,582 feet. The elevation was 270 feet. The boring was entirely in sandstone and the limestone was not reached. Oil and gas were struck at 1,550 feet, and the well was fitted for pumping and was pumped in 1901 from June 25th to Sept. 21st, in all 39 days, yielding in this time 949 gallons. In 1902 it was pumped from May 22nd to July 24th, in all 25 days, the yield being in all only 75 gallons, or an average of 3 galls. per day for the latter period. In August the well was flowing salt water only. The total recorded oil from this well was 1,024 galls.

Well No. 2 is situated about 100 yards south of the last. The elevation is 230 feet. It was commenced on August 5th, 1901, and finished on October 13th at a depth of 1,591 feet. Oil and gas were found in small quantities at 1,570 feet. The pumping log of this well gives an output of only three gallons.

Wells Nos. 4, 5 and 6. Well No. 4 was commenced on August 15th and finished on November 11th, 1901. The elevation was 276 feet, at a point one quarter of a mile east of last. The depth of the boring is uncertain but from 2,100 to 2,200 feet, at which point the limestone was reported. No oil found but salt water was met with. The boring was in sandstone and shale all the way.

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Well No. 5 is about 300 yards south-west of the last. The elevation is 200 feet. It reached a depth of 2,200 feet and shows of oil were found at 1,349 and at 2,140 feet. About three barrels are reported as taken out, probably by bailing, as no pumping log exists, and the well was abandoned. The last show of oil is apparently near the contact of the limestone with the sandstone.

Well No. 6 is about 150 yards west of No. 2. The elevation is 246 feet, and it reached a depth of 2,360 feet to the limestone. A very small trace of oil was reported at 2,340 feet, which was of no importance, and the well was abandoned, no oil being taken out.

Well No. 8 is on the bank of a small stream about 600 yards south-west of the last. It reached a depth of 2,394 feet, and the limestone was struck at 2,340 feet, where a small trace of oil was found. The well was shot without beneficial results and then abandoned. The elevation of the site is 210 feet. Salt water was struck in the upper part but cased off. Wells Nos. 8, 11 and 12.

Well No. 11 was sunk on the bank of the York river on the line between blocks 40 and 41. The elevation is 150 feet and the depth reached was 1,924 feet, the limestone being struck at 1,900 feet. Found salt water with a little oil at 1,490 feet in the sandstone, but the oil was of no importance, and the well was abandoned.

Well No. 12 is situated on the bank of the York river at the mouth of a small brook on block 39. The depth reached is given as 1,500 feet without any trace of oil being found. A band of black shale was passed through at 280 feet. This location is about midway between the Point St. Peter and Mal bay anticlines.

In addition to the records of wells already given it may be said that the International Company bored a well in block 41, on a small brook which flows into the York river near the location of No. 6 of the Petroleum Oil Trust. The site was evidently chosen from the fact that several oil-springs occur in the vicinity, one of which is of quite large size. A line of fault crosses the area a short distance south-west of the location and a high ridge of sandstone rises to the north-east, while the limestone is brought up by the fault just to the south-west. The dip of the rocks is to the south-west at an angle of 16 degrees. The boring was carried to a depth of 1,700 feet in sandstone throughout, as would naturally be expected from the position of the rocks in the area, and no trace of oil was found. The limestone to the south is bituminous, and the oil-springs evidently proceed from the line of fault, there being three of these springs on this line in a distance of about half a mile along its course. International Cos. well.

The pumping logs. The study of the pumping logs shows certain features relating to the occurrence of oil in some of the wells which is of considerable importance. After the wells have been standing for some days or months there is manifestly an accumulation of oil in some of them which has gathered by slow percolation from the surrounding rocks, probably along fissures. Thus, when pumping operations were commenced in 1901 on some of these, the output for several days was fairly large, but in a short time it fell off to a few gallons or even quarts, and in some cases entirely ceased.

The first date of pumping appears to be March 9th, 1902. Thus in well No. 31, which is in the group on block 40, the first day's yield is given as 260 gallons, on March 15th the same amount, but on the 22nd the output was only 80 gallons, on the 27th only 40 gallons, on the 28th only 20 gallons, and on the 30th 18 gallons. On April 3rd, after an interval of three days, the outflow was 38 gallons, then daily for three days it pumped 15 gallons. After six days rest it amounted to 37½ gallons on April 19th. On May 6th, after sixteen days rest, the outflow was 87 gallons, or an average of only 5½ gallons per day. This yield gradually diminished, till on July 11th, when the pumping ceased, it was only two gallons, after an interval of 16 days rest. The total amount of oil by log from this well was 1,055 gallons, or a little over 20 barrels from 27 days pumping.

In some of the wells the pumping record shows a considerable irregularity. Thus in well No. 34, the yield on March 16th, the first date of pumping, was only 10 gallons. On the 23rd, after an interval of six days, it was 40 gallons. On May 1st. it was also 40 gallons. From this date it was pumped regularly till the following September, the yield varying from five gallons per day to 30 gallons, or a daily average for pumping days of about 10 gallons per day, or, for the whole period, of 5½ gallons. In 1902, for the three days in April from the 22nd to 24th, the yield was 247 gallons. Then water only for 14 days, and for seven days in May, from the 9th to 24th, it varied from a quarter gallon to one gallon, after which the yield was water only to August 9th, at the time of our visit. The total yield from this well per log was 1,744 gallons for the two seasons' pumping.

Logs of wells. Well No. 32 began pumping on March 22nd, 1901, and was pumped until September 21st. of that year. In 1902, it was pumped from April 26th to August 9th, the day of our visit, in all 188 days. The total yield was 1,745 gallons, or an average of about 9½ gallons per day. In the latter year the yield varied greatly, ranging from one gallon per day upward, and for the last month averaged about four gallons per day.

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Well No. 19 was pumped from May 22nd, 1901, to September 21st, and in 1902 from April 22nd to August 9th, in all 163 days. The total yield is given as 850 gallons, or an average per day of about four gallons. From May 1st, 1902, the yield was for the most part about one gallon daily, occasionally reaching three gallons.

Well No. 17 was pumped from April 24th, 1901, till August 22nd. The total yield was 126 gallons for 16 days' pumping during this time, or an average daily flow of about one gallon.

Well No. 15 was pumped, in 1901, from May 25th to August 5th, with a total yield of 231 gallons, or a daily average of about three gallons.

Well No. 11 was pumped for four days only. On May 25th, 1901, it gave four gallons, on June 4th, 50 gallons, on June 28th, 17 gallons, and on July 6th only four gallons, in all 72 gallons, or less than two gallons per day for the whole time.

Well No. 22 was pumped for three days only in 1901. On June 1st, it gave 600 gallons, on June 3rd, 200 gallons, and on July 26th, only 10 gallons.

Well No. 12 was also pumped for three days only. In 1901, June 26th, 30 gallons; July 3rd, it gave one gallon; on July 26th, 55 gallons; in all 86 gallons.

Well No. 16 gave on June 10th, 1901, 150 gallons. Nothing further recorded, output probably obtained by bailing.

Well No. 13 gave on June 12th, 40 gallons, and on July 6th, only one gallon.

Well No. 10, on June 5th, gave 125 gallons, on the 24th, eight gallons, and on the 27th, only one gallon.

Well No. 14 gave on June 25th 16 gallons, on June 26th only one gallon, and one gallon also on July 6th.

Well No. 27 was pumped, in 1901, from April 5th till August 15th. The yield for this period was 385 gallons, or an average of rather more than $2\frac{1}{2}$ gallons per day. In 1902 it was pumped from June 18th till August 9th, with an output of 192 gallons, the daily yield steadily declining till August, it averaged about one gallon to one-half gallon per day. The total yield of this well was 577 gallons.

Well No. 20 was pumped from March 28th, 1901, till September 21st, with a yield of 1,042 gallons. In 1902 it was pumped from April 2nd till August 9th, with a yield of 708 gallons. In all a total of 1,750

gallons. The daily average in 1902 was about two to three gallons for the greater part of the time. An interesting point in connection with this was the yield for April 21st, which was only two gallons, while on the 22nd it is given as 280 gallons, but this on the 28th had fallen to seven gallons.

Total amount of oil pumped, 1901-1902. The total amount of oil as per these pumping logs taken out in 1901 and 1902 amounts therefore to 9,384 gallons, or allowing 45 gallons to the barrel, about 208 barrels. In addition to this the Canada Petroleum Co. give an output of 1,227 gallons, or about 27 barrels.

This is exclusive of the different amounts claimed to have been lost by fire and otherwise during the period of borings, of which no reliable estimate can be obtained.

Occurrence of oil. From a careful consideration of all the data at present to hand regarding this field as a producer of oil in economic quantities, it must be said that the outlook can scarcely be regarded as favourable. There are no well-defined oil-sands, such as are recognized in the true oil territory, and where oil has been obtained in reported large quantities it would seem to occur in isolated pockets only, since the continuation of the borings to a greater depth has given no favourable results. That oil in small quantities exists in different portions of the sandy strata, and occasionally also in the limestone is evident from the records, but so far it is plain that nothing which can be regarded as of economic value has been found.

Unfavourable conditions for oil. There are practically no data obtainable by which wells may be located with even a fair prospect of finding oil in paying quantities. The anticlinal theory which is applicable to the western oil fields as being favourable to the occurrence of oil, is not supported by the results obtained in this area, and the presence of numerous faults, with steeply inclined strata, and the abundance of salt-water which is encountered in most of the borings already made, are all against its successful exploitation. At the present time the location of bore-holes is entirely a matter of chance; and though holes have been sunk to a depth of over 3,500 feet such deep borings have only been made at enormous expenditure, and in every case without any satisfactory results. The theory that the oil occurs at the contact between the sandstone and the limestone must also be abandoned. The supposition that the presence of oil-springs at different points is a favourable indication of large underlying deposits of oil has been clearly disproved, and since these usually occur along or near lines of fault must be considered as adverse to that hypothesis. The expenditure of such large sums of money as have been made during the last fourteen years, and the

Oil springs.

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absolute lack of results in finding oil in paying quantity, may well be taken as conclusive that no satisfactory results will be obtained from such further expenditure in this direction.

THE ALBERT SHALE DEPOSITS OF ALBERT AND WESTMORLAND
COUNTIES, N.B.

R. W. Ellis, LL.D., F.R.S.C.

The following report on certain economic aspects of the Albert shale deposits of Albert and Westmorland counties, New Brunswick, may be regarded as, in most respects, supplementary to the general report on these rocks, published in 1876-77, in the annual volume of the Geological Survey by Dr. L. W. Bailey and the writer. At that time a somewhat exhaustive examination of these shales and of the associated rocks was carried out throughout their whole extent in the two counties mentioned, more particularly with reference to the presence of the valuable mineral albertite, which had for some years been largely and profitably mined at the 'Albert mines.'

Former
reports.

In the course of that examination the presence of heavy beds of what is usually known as 'oil-shale,' now styled by some persons 'cannelite,' was observed; and while these heavy bands were not found to bear any close association with the deposits of albertite, their undoubted value as a possible source of supply for oil by distillation was clearly recognized.

The mode of occurrence of these heavy oil-shales is quite distinct from that of the albertite. In the case of the latter the mineral occurs in the form of true veins, which sometimes follow the lines of stratification of the inclosing shales, but which also often traverse them at well defined angles. This aspect of the question has so often been discussed by various writers that further enlargement on the subject is unnecessary, and the once stated opinion that the albertite occurred as a true bed, similar in this respect to bituminous coal, may now be altogether laid aside.

Occurrence of
Albertite.

On the other hand the massive 'oil-shales' occur as true inter-stratified beds in the bituminous shale series.

Character of
oil-shales.

As to the geological position of the shales as a whole it may be remarked that somewhat diverse opinions have been held from time to time by different observers. Thus in the early days of their investigation it was supposed that they represented an integral portion of the

Horizon of
Albert shales.

Lower Carboniferous formation. This conclusion was reached from the presence in certain bands of the shale of remains of fossil fishes and plants which were then supposed to have a Lower Carboniferous aspect and to definitely fix their horizon. The investigations made in 1876 showed that however true this might be, the mass of the shales themselves occupied a position entirely unconformable to the true Lower Carboniferous sediments, associated with limestones and gypsum, and which are well defined throughout the area, and that with good reason they should therefore stratigraphically be assigned to a lower horizon or regarded as of Devonian age. It may be added that this view as to their position is now generally accepted by those most familiar with their study in the field.

Extent of the
deposit.

As for the extent of the Albert shale formation it may be said that it has been traced for a distance of over thirty miles from east to west. The shales are not, however, continuously exposed throughout this whole distance, since they are sometimes covered over by overlying sediments, either of Lower Carboniferous or Millstone-grit age. In Albert county they occupy a position for a considerable portion of their area along the north flank of the range of hills known as the Caledonia mountains, the rocks of which consist of granites and other intrusives along with gneiss, schists of various kinds, hard slates, &c., which are regarded as of Pre-Cambrian age. The course of this range is north-east and south-west. East of the Albert mines the crystalline rocks are not seen, except in a small outcrop near Calhoun's mill on the Memramcook river, a few miles north of Memramcook village, on the Intercolonial railway. The shale deposits extend onward across the Petitcodiac and Memramcook rivers, showing in the banks of both streams and at different points over the intermediate area, as at Beliveau, Taylorville and along the roads between Dorchester and Memramcook.

Areas in
Albert Co.

In the Albert county area the best exposures are seen at the Albert mines, four miles west of the Petitcodiac river. In the intermediate space they are, however, largely concealed by the overlying Lower Carboniferous formation which includes the gypsum deposits of the Hillsborough Plaster Co. Further west they are well seen at Baltimore, six to eight miles distant from the Albert mines, outcropping along the courses of the several branches of Turtle creek and in numerous outcrops on the hillsides. Though they have not been traced continuously between these two places owing to the fact that they are sometimes concealed by red and gray marls of the overlying formations, it is regarded as very probable that they form a continuous belt for the entire distance.

Albert mines
and Balti-
more.

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West of the Baltimore areas the shale belt is continuous for a further distance of some four miles to the south branch of Prosser brook, where it terminates against a spur of the old mountain rocks. The shales, however, again reappear to the west from beneath the Lower Carboniferous sediments at Pleasant valley and again at Mapleton, the latter place about three and a half miles east of Elgin Corner, where they form a band about two miles in length. West of Elgin they are also exposed along a branch of Pollet river and form a narrow band along the course of the stream. This outcrop practically marks the western limit of the shales in Albert county.

Elgin and
Mapleton.

The exposed width of these shales is nowhere very great, and in Albert county seldom exceeds half a mile, but in Westmorland this breadth is in places somewhat greater. The rocks of the area are frequently much disturbed, being affected by numerous faults and often inclined at high angles. At the Albert mines and also at Beliveau and Taylorville, this feature is common, and several well-defined anticlinals are visible at these places. In the Baltimore area the shales are more regular, with a prevailing dip to the north at angles of 15 to 25 degrees.

Faulted
character.

In certain areas the shales are underlaid by a hard green conglomerate which is made up of the debris of the mountain rocks. This feature is well seen on Pecks' creek, west of the Albert mines, as well as at Beliveau, at Mapleton and at the locality west of Elgin Corner.

Conglome-
rates.

The thickness of the shale formation has been estimated at about 1,000 feet or possibly something more, since owing to their folded and faulted character the exact determination of their volume is rendered very difficult. In their physical characters they vary somewhat in different localities. Some of the beds are comparatively sandy, constituting in places a bituminous sandstone, while other portions are quite thin and papery. Occasionally thin bands of a hard dolomitic-looking limestone form interstratified layers, but the bulk of these is small. As a rule the shales and sandy layers are bituminous throughout the formation, but certain portions have this feature much more largely developed than others.

Thickness
and character
of shale.

Small veins of the black shining mineral albertite are quite abundant at several localities. As a rule these are too small to be mined profitably, and, with the exception of the large vein which was worked so successfully for many years at the old Albert mine, no deposits of this mineral have elsewhere as yet been found in paying quantity. A peculiar feature of this mineral is its occasional association with both

Occurrence of
albertite.

the underlying and overlying rocks. Thus at several points it is known to occur in the old rocks of Caledonia mountain as small threads. In this case it is probably due to infiltration from the overlying shales: while in the upper series of Lower Carboniferous limestones, gypsum, and conglomerates it is occasionally observed in small irregular veins or stringers, and even in the still higher sandstones of Millstone-grit age it is sometimes found in veins of considerable size, so much so that, at what is known as the East Albert mine, attempts have been made to mine the deposit of albertite. In such positions the mineral may be regarded as a distillate, newer than all the rocks in which it occurs.

The East
Albert mine.

The old Albert
mine.

At the old Albert mine the deposit which was evidently of the nature of a true fissure vein, was worked downward to a depth of nearly 1,400 feet from the surface. In the lower levels the vein matter frequently occurred as a cemented mass of shale and albertite, the substance being too impure for shipment, and large quantities of this material were thrown out in the dumps where it can be readily seen. In the case of the albertite itself also, owing to the great purity which was at that time required for shipment, quantities of the mineral were thrown aside with the waste. This albertite can also be everywhere observed in the mass of the dump and around its sides where it has been washed out, and many of these pieces are of good size and quite free from any impurity. On the whole it may be said that many tons of pure albertite have been thus thrown away.

Other veins
untested.

It was supposed at the time mining operations were suspended at this mine that the mineral in paying quantities was practically exhausted. It does not by any means follow, however, that this was the actual state of the case. Several small veins have long been known to exist which have as yet been practically unopened, and their actual value as yet not fully ascertained, and one of these, situated on the north side of an anticlinal near the main road through the old village, shows at the surface an exposed breadth of at least two feet. This vein, which appears to be a branch of the main vein which was worked for so many years, is certainly worthy of being tested to prove if it does not extend, and even increase in size at greater depths, a possibility which, from the irregular character of the main vein, is likely to occur.

The oil shale
bands.

The 'oil-shale bands' to which this report is especially supposed to relate, occur in different parts of the shale body. They consist of thick seams of a dense, usually black and massive rock, radically differing from the ordinary bituminous shales, though they have usually

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been regarded and described under that head. They form regular beds, extending over long distances, and are thus entirely unlike albertite in that the vein structure of that mineral is entirely absent.

These beds of 'oil-shale' range in thickness at the Albert mines from three to nearly or quite six feet, and at least five of these bands or beds have been recognized at this place. The rock is very compact, breaking with a roughly conchoidal fracture, with a veined or woody aspect on weathered surfaces, apparently entirely free from grit of any kind, since it can be readily cut with a knife without appreciably dulling the edge, is very rich in oil, and certain portions readily ignite in the flame of an ordinary match. By analysis these dense 'oil-shales' are reported to yield, in portions at least, and the rock appears to be quite uniform throughout the largest beds, from 60 to 65 gallons of oil per ton. Along the course of Frederick brook, which traverses the area to the north of the main line of old workings, these strata of 'oil-shales' show in successive bands, separated by other shales, often brown in colour and sometimes highly bituminous, though the percentage of oil in these has as yet not been fully determined. It is probable however that a large portion of these intermediate shales will yield not far from 30 gallons of oil per ton. Their oil content.

These black 'oil-shales' are also well developed at Baltimore and at Taylorville. At the former locality, four or possibly five of the bands occur, varying from three to six feet in thickness; and as far back as 1864, works for the extraction of the oil by distillation were erected and the industry carried on for several years. The discovery of the oils of the west, however rendered crude oil so cheap that in face of a duty of ten cents per gallon on the output, the greater part of which went to the United States for refining, the industry was obliged to close down. The rich bands at Taylorville were also quarried to some extent for the same purpose. Thickness of bands.

The black bands are well exposed on all the branches of Turtle creek in the Baltimore area and they have been opened by several drifts on the hill-sides. The thickness of the several bands is thus well established in this district. On the west branch of Turtle creek, beyond the Stewart farm the colour of the oil-bands becomes grayer but the mass of the rock is filled with blackish streaks, and the percentage of oil from these beds, of which two are known to occur, is apparently greater than in the black bands, reaching by analysis as much as 80 to 85 gallons per ton. The thickness of these two gray 'oil-shales' on the west branch is stated by Mr. William Hall, formerly-manager of the Spring Hill coal-mines, to be 20 and 21 feet. They Baltimore and Turtle creek.

have been opened to some extent and some tons extracted. The rock kindles readily on application of a lighted match to thin pieces.

Bands at
Taylorville.

The number of 'oil-shale' bands at Taylorville was not ascertained, though there are several in the area. In character they are like the bands at the Albert mines, and the quarry from which they were mined is in a field near the road crossing from Upper Dorchester and about one mile from the Memramcook river.

The quantity of material in these rich shale bands is therefore practically unlimited, and has been estimated by several mining engineers who have examined the property at as much as 270,000,000 tons.

Extent of the
Albert shale
deposit.

How far these Albert shales extend to the northward beneath the Lower Carboniferous and Millstone-grit sediments is at present uncertain. It is not supposed, however, that they underlie the whole Carboniferous basin, since east of the Petitcodiac and Memramcook rivers the structure is apparently basin shaped. They may, however, be repeated at several intervals. The most northerly recognized outcrop yet seen is on the north side of Indian or Lutz mountain, where on the road leading to the McLaughlin road they are exposed for some distance and apparently extend down the slope of the hill overlooking the valley of the Cocagne river. The shales of this locality resemble very closely those of Albert county and are probably of the same horizon, though they are much less rich in bituminous matter where exposed.

Lutz mountain
band.

From Dr. Oliphant's paper on the oil industry taken from the Annual Volume U.S. Geological Survey, Vol. XX., 1898-99, the following figures are extracted :—

Statistics.

Quantity and value of the oil-shale produced in Great Britain, mostly in Scotland.

1890	2,212,250 tons.	£608,369
1891	2,361,119 "	707,177
1892	2,089,937 "	522,484
1893	1,956,520 "	489,130
1894	1,986,385 "	496,506
1895	2,246,865 "	561,716
1896	2,419,525 "	604,881
1897	2,223,754 "	555,936

Remarks.

A ton of bituminous shale yields very nearly an American barrel of petroleum distillate, and its cost is very nearly that of a barrel of crude laid down in Scotland.





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A hundred gallons of crude shale oil obtained by distillation of the bituminous rock yields about 30 gallons of fair illuminating oil, 16 gallons heavy oil, 14 gallons paraffine scale, 8 gallons lighter oils, and 5 gallons of petroleum spirits, while the residue is tar and coke, suitable for fuel only. Each ton of shale yields also about 50 lbs. of sulphate of ammonia.

Analysis of
crude shale
oil.

Profits.

Broxburn Co., 1898, 6 per cent on preference stock and $8\frac{1}{2}$ per cent on common.

Profits of
manufacturer
in Scotland.

Oakbank showed a profit of \$55,000 and a 5 per cent dividend declared.

Pumphreston, an apparent profit of \$105,000, dividend 6 per cent.

Loss.

Young's Co., deficit of \$40,000.

Holmes Co., shrinkage of \$30,000.

Clippens Co., loss of \$70,000. Towards end of 1898, all stocks showed great improvement.

REPORT ON THE GEOLOGY OF PRINCE EDWARD ISLAND WITH REFERENCE
TO PROPOSED BORINGS FOR COAL.

Dr. R. W. Ellis.

In the year 1883, several weeks were spent by the writer in a brief study of the geological formations found on Prince Edward Island and a short report thereon was given in the Geological Survey Report for the years 1882, 1883-84, more especially as relating to the western and southern portions of the island. Sufficient data were however at that time obtained to warrant the conclusion that the rocks found in the eastern portion were practically similar in age at least to those which were more carefully examined.

Work of 1883.

In that report the opinion was expressed that the views put forth by Sir William Dawson in his report on the island in 1870, that the greater part of the red sandstones and shales of which the island rocks are largely composed, were of Triassic age, would need to be somewhat modified, and that, in so far as then examined, these rocks more properly belonged to the Upper Carboniferous series, or possibly to the

Sir Wm.
Dawson's re-
port, 1870.

Permian. The term Permo-Carboniferous was therefore chosen as best meeting the nomenclature of the question.

Change of
view.

The areas assigned by Sir William Dawson, in his report, to the Upper Carboniferous formation were confined to a strip on the western shore from West Point to North Cape, and to certain areas east of Charlottetown and near the entrance to Charlottetown harbour, of which, however, he did not consider the age as actually determined. The detailed examination of the island in 1883, however, showed that such a separation was not possible, but that so great was the similarity in the rock formations over the greater part of the island, the whole or at least the greater portion should be included under the same head.

Work of
Francis Bain.

Subsequently Mr. Francis Bain, working independently, and largely in connection with the plant remains which are found at many points throughout the whole province, came to a similar conclusion as to the Upper Carboniferous age of the greater portion of the island rocks from the fossil evidence. These conclusions were presented in a paper read before the Royal Society of Canada in 1885 by Sir William Dawson, and with his comments thereon were published in the *Canadian Record of Science*, Montreal, vol. I., for that year. A previous paper by Mr. Bain relative to some fossils which he had found there was also printed in the *Canadian Naturalist* for 1881, in which the Upper Carboniferous character of the plant remains was indicated. The Triassic rocks were at that time regarded as confined to a limited area in the vicinity of New London, on the north side of the island, and the evidence upon which this separation was based was the finding some years before of the fossil *Bathynathus borealis* which was then regarded as of Triassic age. With the exception of this fossil from the New London area, it may be said that all the evidence points to the opinion that the red sandstones and shales of which the island is largely composed may all be assigned to the Carboniferous horizon, or, as some geologists prefer to call them, Permian.

Supposed
Triassic area.

Importance of
establishing
age of rocks.

The establishing of the age of these rocks as Upper Carboniferous is important in view of the proposed explorations for coal by boring. Though there are nowhere visible on the island, any rock formations which can be assigned to the underlying series of the productive coal-measures, such as occur in the province of Nova Scotia, the fact that their age is Upper Carboniferous instead of the higher or Triassic formation, shows that the probable depth at which coal-measures may be reached, if indeed such rocks underlie the island anywhere, is much less than was originally supposed.

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The key to the problem regarding the occurrence of underlying deposits of coal on the island itself, cannot be ascertained from the study of the rock formations there exposed. There is in the province no actual data on which to base the occurrence of the lower or productive measures. In order to arrive, if possible, at some definite conclusion on this subject, some time was spent in an examination of the formations along the adjacent shores of New Brunswick and Nova Scotia, where rocks similar to those which occur over a large part of Prince Edward island, also occur.

Comparison with New Brunswick and Nova Scotia rocks.

In New Brunswick a narrow margin of the red sandstones, conglomerates and associated shales of the upper series is found at several points along the shores of the Gulf of St. Lawrence, as far north as Shippegan island. They are also well seen in the Tormentine peninsula where they pass downward into underlying gray sandstones, which here are supposed to represent the lowest portion of the Upper Carboniferous in this direction.

Cape Tormentine.

Near Shediac and along the east coast of New Brunswick, these newer rocks rest upon gray sandstones and conglomerates which have been regarded as of Millstone-grit age, and the productive coal-measures have not as yet been recognized in this part of the province. While the gray beds of the two somewhat widely separated divisions of the Carboniferous rocks present certain points of similarity, there are some features which render their separation possible. The sandstones of the upper series can be generally distinguished by being much softer and less coherent in character than the gray grits and conglomerates of the Millstone-grit series.

Shediac and vicinity.

South of Baie Verte, this difference in character can be readily seen on the road leading across to Aulac. Thus, at the latter place, what is known as the Aulac ridge rises near Aulac station on the Intercolonial railway, and extends in a north-east direction, in the direction of Pointe de Bute and Tidnish. The rocks of this ridge are gray grits and quartz-pebble conglomerates, and have a distinct anticlinal structure.

Baie Verte and Aulac.

About seven miles south of Baie Verte the Millstone-grit outcrop terminates, but at Halls hill, which is about two miles further north, a series of gray sandstones comes these rocks in, and have been cut down along the roadway. These belong to the newer series, and are soon overlaid by the soft red beds which are so conspicuous along the shores about Baie Verte, and thence east to Tidnish and on to Pugwash in Nova Scotia. In these red beds are bands of conglomerates in which the pebbles are

Upper conglomerate rests on Millstone-grit.

largely made up of bright red shale, and thin bands of impure red limestone also occur at several points. The series as a whole is quite distinct from anything seen in the Millstone-grit formation, and precisely resembles the rocks seen along portions of the shore of Prince Edward island, from Cape Egmont to Wood islands, as well as at many other points in that province. In New Brunswick they are also well exposed at Cape Tormentine, and along the shores of that peninsula at many places, while at Bayfield corner, and around Port Elgin they are underlaid by the grayer members of the upper series, which also show on the road between Shediac and Pointe du Chêne.

The formation
in northern
Nova Scotia.

These soft red rocks with occasional gray sandstones also appear along the north side of Nova Scotia in the counties of Cumberland, Colchester and Pictou. Here for the most part they overlies directly, in so far as yet known, rocks of Lower Carboniferous age without the interposition of the Millstone-grit or productive coal-measures. This contact appears to be of the nature of an overlap since there is no indication of faults between them. It is probable, therefore, that in this northern portion the true coal measures have never been deposited along this side of Northumberland strait.

Pictou and
Merigomish.

Further east the rocks of the newer series are exposed along the south side of Northumberland strait to a point several miles east of Merigomish island, or about twenty miles east of Pictou harbour. At this place they rest upon sediments of Silurian and Cambro-Silurian age with which are associated granites and other igneous rocks. East of this the red rocks of the upper series are not exposed, either along the shores of Nova Scotia proper or on the Island of Cape Breton. There would therefore appear to be a gap of considerable extent in the sequence of the geological formations in this part of the province.

Anticlinal
structure in
P. E. I.

The structure of the rocks in Prince Edward island indicates the presence of several lines of anticline which extend across Northumberland strait from New Brunswick and Nova Scotia, and traverse the island in a general north-east direction. In order to locate these as precisely as possible an examination was made of the whole shore line, since but little information regarding structure could be obtained from the few exposures seen on the surface of the island itself. In fact, owing to the presence of much false bedding, the occurrence of dips and strikes thus seen were of but little value. The coast sections, however, are fairly good, though there are occasional long stretches occupied by sands where rock outcrops cannot be observed. The general succession of beds along the greater part of the shores can, however, be fairly well ascertained.

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Apparently the lowest rocks of the Island series are dark red sandstones with occasional beds of conglomerate in which the pebbles are of soft bright red shale, with irregular beds of impure limestone, generally reddish in colour, but at several points a gray limestone also occurs. Pebble conglomerates are also seen at several places, as at North cape, and on the shores of Mill river south of Alberton, the pebbles being of quartz with, occasionally, pieces of hard metamorphic rocks. On the ridge about ten miles north of Wood island, and on the road to Cardigan, a deposit of well rounded pebbles is seen which have evidently been derived from beds of these conglomerates in the vicinity, and traces of which can be recognized in place.

Rock of lowest division.

In character most of these red rocks are very similar to the beds seen in the sections along the Wallace and Waugh rivers on the north side of the Cobequid mountains in Nova Scotia. They are sometimes interstratified with beds of grayish sandstone which are usually thin and irregular, the gray colour apparently due to the elimination of the red colouring matter through the agency of plant stems which frequently occur in these lowest beds. This character is well seen at St. Peter island, near the entrance to Charlottetown harbour as well as on Governor island near by. Further east similar gray irregular beds are exposed in parts of the section at Gallas point.

Similar to rocks in Nova Scotia.

On the west coast the nearest approach to this feature was observed on the shore at Campbelltown, where, underlying the great series of red shales and sandstones which form the cliff between Big Mimene-gash and Wolf cape, coarse reddish grits with grayish bands crop out at the base of the bluff. While these may not be quite so low in the series as some of the lowest beds of Gallas point, they apparently indicate the lowest members of the series in this direction.

Campbelltown and Mimene-gash.

These are overlaid by a considerable thickness, probably aggregating several thousands of feet, of soft red sandstones and shales, occasionally with bands of impure limestone, which are seen over the greater portion of the surface of the island. Much of the sandstone is a dark red or red-brown, and these pass up into red sandstones with shales which continue to the summit of the formation. Throughout this series there is no very great variety as regards the character of the rocks themselves, and all may be included in the same general group. The usual dips of the strata are to the north-west and south-east. They are usually at low angles, rarely exceeding ten degrees, and more often ranging from two to six degrees. Occasionally however this inclination is as much as fifteen to twenty degrees for short distances. These seem to indicate slight disturbances of a local nature.

Character of strata.

Local fault. Only two small breaks were noticed, of which one was on the south shore, about one mile west of Rice point, which is at the west entrance of Hillsborough bay where there is a downthrow of about thirty feet, and a slight displacement on the north side of Governor island of less than ten feet. Eruptive rocks were seen at only one place, on Hog island in Richmond bay, where a dyke of diabase cuts the soft red sandstones and has altered these for a short distance along the line of contact.

Six anticlines in Prince Edward island rocks. The anticlines noticed in connection with the structure of the Island rocks are apparently six in number. Of these the most northerly comes across from the New Brunswick shore in the vicinity of Richibucto head, and is not seen on the island proper as its course extends along the north-west shore a short distance out from the coast line. This may be styled the Mimenegash anticline. The rocks along this part of the coast, where observed between West cape and North point, all have a well-defined south-east dip, the strike being approximately parallel to the line of the shore, with angles ranging from two to seven degrees. On the shore near Little Mimenegash creek, a bed of gray limestone occurs, visible only at low water, which has been locally quarried to some extent both for lime-burning and for building stone, the church at Tignish being built from stone taken from this locality. These gray limestones were not seen at any point on the surface of the island.

1st anticline Mimenegash.

2nd anticline Egmont bay. The second anticline is regarded as crossing the strait from the vicinity of Shediac point, north of Shediac bay on the New Brunswick shore, to the inner point of Egmont bay near the mouth of Percival river. The shores for some distance on either side of this bay are low and sandy, but there are certain low dips on either side of the island in the line of its supposed direction which should indicate its position fairly well, and it should reach the north shore of the island near Cavendish inlet. This line of disturbance is styled the Egmont anticline, but it is not so well defined as several of the others. Its western prolongation in New Brunswick should connect it with the outcrop of the old rocks in Indian mountain north of Moncton. The dips along the shore at Brae head on the north side of Egmont bay are all to the north at angles of three to five degrees.

3rd anticline Summerside. The third line of disturbance may be styled the Bedeque bay anticline. It apparently extends from a point on the north side of the Tormentine peninsula, a short distance east of Cape Bald, whence it should cross to the vicinity of Summerside and continue to the north side of the island near Cousins pond, about two miles west of Cape

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Tryon. The opposing dips of this anticline, though generally low, are well defined and rarely exceed four to six degrees. On the north side of Bedeque bay the north-west dips are well seen at Fifteen point and at Cape Egmont, and the south-east dips are seen at Indian point, and at Graham and Sea-Cow heads, the inclination here ranging from two to four degrees.

The fourth anticline extends from the extremity of Cape Tormentine in continuation of the Aulac ridge. It apparently reaches the shore of the island between Cape Traverse and Tryon. The opposing dips are well seen on the shore near the Tormentine wharf. They are not well defined on the shore of the island, but, on the road north from Hunter river station to New Glasgow, the axis is well seen at a point about one mile north of the former place. It probably reaches the north shore in the low area about Rustico beach, but good exposures are rarely seen in this direction as much of the coast is occupied by clay and sands.

4th anticline
Cape Tryon.

The fifth line of disturbance is that known as the Gallas Point anticline. This is one of the best defined, along the whole shore of the island. The opposing dips are well seen on the west shore of the point approaching Pownal bay. On the north side of this anticline, the ledges seen on Governor and on St. Peter islands, show dips to the north-west, at angles of seven to ten degrees, and this dip is maintained to the vicinity of Charlottetown. On the west side of Hillsborough bay, the dips can be seen at Rice point and Holland cove, and on the east side at Keppoch and Battery point, as well as along the shores of Pownal bay. Opposite Charlottetown the strata apparently flatten out, and this place probably represents the centre of a syncline. The south-east dips of this anticline are seen at Prim point, and as far east as Pinette river, beyond which, eastward, the shores are generally low and sandy and exposures few, to the vicinity of Wood islands.

5th anticline
Gallas Point.

At this place the dips become reversed, and are again to the north-west and north. These continue as far east as Cape Bear, the inclination of the strata varying from ten to fifteen degrees. The axis of this anticline, which may be styled the Wood Island anticline, evidently lies a short distance seaward, and a syncline must occur between this and Pictou island, which lies ten miles south of High Bank, since on this island a well defined anticline occurs with a east and west direction.

6th anticline
Wood Island.

In the eastern portion of the island, the several anticlines appear to flatten out to some extent, and cannot be so readily recognized. The shores are often composed of heavy deposits of clay, and sand and rock

exposures are not so continuous as farther to the west. The inclination of the strata where exposed, is generally somewhat less than those just recorded.

Syncline.

At Souris the dip of the strata is more northerly, the strike coinciding generally with the run of the shore, as far east as East point. The angle of dip varies from five to ten degrees. There is a syncline in this direction in which East point is situated, and the reverse south-east dip was not seen till we reached Campbell pond, where the beds have a low southerly dip of from two to four degrees. Good rock exposures are rarely seen on this part of the island, since the shores east from Rustico are usually low and frequently formed of sand dunes or of boulder clay.

Thickness of island rock.

The actual thickness of the formation, as seen on the island, is somewhat difficult to determine. According to the estimate of Mr. Francis Bain, who divided the rocks there seen, into three groups, there are in all about 3,000 feet which he arranges thus:—

Estimate by Mr. Francis Bain.

1. A lower series of gray, brown and red sandstones and shales, termed by Sir William Dawson, Permo-Carboniferous with a thickness of about 800 feet. These contain plant stems which have been determined to be of Carboniferous rather than of Triassic age.

2. A middle series, conformable to the last, or nearly so, consisting of red sandstones and shales, with calcareous sandstones, which occupies the greater part of the island, the thickness of which he estimates at 2,000 feet; and

3. Red sandstones and shales, not distinguishable from the last, seen at New London, and having an estimated thickness of 150 feet. These include the Cape Turner beds of the north shore.

Probable thickness at Charlottetown.

It is doubtful if this estimate of thickness covers all the sediments of the island, and it is highly probable that the total volume is considerably greater. Thus making due allowance for false-bedding, and the difficulty of securing correct dips, if we take the section north from the crown of the Gallas point anticline to the supposed centre of the basin at Charlottetown, and allow a dip of seven degrees only, the thickness will amount to not far from 6,500 feet, or with an average dip of only five degrees the total thickness will be not far from 4,500 feet. This last estimate is, however, probably too low.

Comparison with similar rocks in Nova Scotia.

In this connection information obtained from sections made of similar rocks along the French, John and Waugh rivers in that part of Nova Scotia between Northumberland strait and the Cobequid

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mountains will be of value. Most of these sections were very carefully measured by Mr. Hugh Fletcher of the Geological Survey. The rocks in this area consist largely of red sandstones and shales with, occasionally, gray beds of sandstone, and probably carry the formation, as seen on Prince Edward island, to the bottom of the series. It may be said also that in these sections no trace of the productive coal-measures was found, the Upper Carboniferous resting upon the old mountain rocks.

Work by Mr.
Hugh Flet-
cher.

Thus, on the French river a thickness of 4,925 feet was found. In all this there was no trace of coal, further than occurred as the occasional carbonized bark of tree stems. Traces of copper were seen where the ore has been thrown down from solution through the agency of plant stems.

French river
section.

On Waugh river the thickness of the formation was found to be 5,045 feet of red marl and sandstones with occasional gray beds. These were underlaid by a series of red conglomerates which form the lowest portion of the formation and in some places reach a thickness of 1,500 feet. No coal was seen, but traces of copper and some small traces of albertite.

Waugh river
section.

On River John the section in similar rocks gave a thickness for the formation of 8,107 feet. No coal was seen, but the usual occurrence of copper with traces of albertite was observed.

River John
section.

A section measured along the shore from Cape John to Toney river in similar red marls and sandstones to those of the island gave a thickness of 4,622 feet. Occasional gray beds were found.

Cape John to
Toney river.

It is evident, therefore, that in any attempt to reach a formation below the Upper Carboniferous great care must be exercised as to location for boring operations. It may be assumed that any depth beyond 2,500 feet will be practically outside the limit of successful operations, even should coal be found unless in very large quantity. The proposed locations must therefore be selected along those lines on which the lowest rocks of the series are exposed.

Conditions for
proposed
boring.

As the axes of the anticlines apparently dip somewhat towards the north and east, it would appear, in so far our examinations have extended, that the most suitable points for trial will be, on the north-west side at Campbelltown or Mimenegash, on the south-west of Summersidé, and on the south and east at Gallas point and Wood islands.

Location for
bore-hole.

Coal in New
Brunswick.

Yet with this knowledge of locations, the probability or possibility of success as regards finding coal in workable quantity by any boring operations must still be regarded as very doubtful. Thus along the western portion of the island the only seams likely to be encountered will be those known to occur in that part of New Brunswick adjacent. As has already been stated no defined horizon of the productive coal-measures has yet been found in that direction, the thin seams known to occur at Coal branch, of a thickness of twelve to eighteen inches, belonging to the Millstone-grit formation, to which horizon also must be assigned the still thinner seam which has been found on the lower part of the Cocagne river.

Tormentine
peninsula

Further east on the Cobourg road near the road from Sackville to Bristol, about ten miles south of the shore in Tormentine peninsula a small seam of four inches occurs in the Upper Carboniferous rocks, and a like seam of from two to four inches is seen near Dupuis Corner, a few miles west of Cape Bald. These are of no value from the economic standpoint.

Big Caribou
island, N.S.

In Nova Scotia along the north shore in similar rocks, a small seam occurs at several places. Thus in the boring on Big Caribou island, west of Pictou, a seam of seven inches of coal was reported, and also near Toney river, some miles further west. On the shore opposite Pictou, at Abercrombie point, a seam of fifteen inches occurs, and this outcrops at several points in the area between the East and Middle rivers near their entrance into Pictou harbour. A band of oil-shale also is found associated with the coal. Further east, on the north-west end of Merigomish island a seam eighteen inches thick shows on the beach. These seams east of Pictou apparently occur low down in the Upper Carboniferous formation.

Pictou and
Merigomish.

Port Hood
and Mabou.

As regards the extension westward of the seams which are found on the west side of Cape Breton Island at Port Hood, and in the Mabou district, it would appear that these are cut off seaward a short distance from the shore, since Lower Carboniferous sediments are seen on the islands off the former place, and the productive measures are probably affected by faults which would render their continuation to the island very doubtful.

Possibility of
finding coal
by boring.

The occurrence of many faults in the Pictou coal basin and the fact that, east of New Glasgow, the Upper Carboniferous rests directly upon the Millstone-grit where the former is developed, renders it extremely improbable that the thick seams of the Pictou basin extend beneath the rocks of Prince Edward island, so that any borings on

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the south side of the island would penetrate only the thin seams of the upper formation already described as occurring along the north shore of Nova Scotia. There is a possibility of some one of these being struck in the borings at Wood islands or Gallas point, provided such seams as seen in Nova Scotia are continuous to any distance. The probability however is that such seams have merely a local development.

While therefore the outlook for finding coal in large quantity by boring, either in the Upper Carboniferous formation of Prince Edward Island, or in any formation underlying, is not very encouraging, it may be stated that the points suggested at which such trials should be made, will, if the borings are properly conducted, furnish much valuable information as to the actual sequence of formations, and there is always the possibility that other conditions than are warranted by the surface indications may be disclosed. Such possibilities can only be ascertained by a judicious expenditure of money, but in such expenditure, unless a proper supervision of the borings from day to day is maintained, and the log is properly kept, much of the beneficial results will be entirely lost. Prospect unfavourable.

THE CARBONIFEROUS ROCKS OF CHIGNECTO BAY.

Professor H. S. Poole.

I beg to report that in accordance with instructions received from the Acting-Director of the Geological Survey, I examined in more detail than was possible last year, the several series of exposures about the head of the Bay of Fundy that supply connecting links between the wide expanse of Carboniferous gray beds which extend in an unbroken series from the Baie des Chaleurs to Sackville in New Brunswick and the measures of Nova Scotia, typified by the Joggins section in which thick workable beds of bituminous coal occur. The former series, in so far as yet known, do not contain similar deposits of corresponding value. Work by Mr. H. S. Poole.

I had also an opportunity of discussing on the spot some of the important structural features with both Mr. H. Fletcher and Dr. R. W. Ells of the Survey staff. Mr. Fletcher is thoroughly conversant with the range of the Carboniferous over all of Nova Scotia, but hitherto was unfamiliar with the rocks of New Brunswick; and Dr. Ells had been engaged in the study of these rocks in the last named province in 1881-84.

Spicer's cove
rocks.

On July 21, with Mr. Fletcher I went to Sand River, N.S., and thence to Spicer's cove on the Bay shore, a region where Sir J. W. Dawson had assumed that Millstone-grit beds were brought to the surface by faulting parallel to the Cobequid range. This assumption, it is said, was not based on personal observation, but on inspection of transmitted hand specimens, and the late survey has failed to confirm it.

The Sand
river fault.

Repeated visits have been paid by Mr. Fletcher to both the Millstone-grit series of the Joggins section and to these beds for the sake of comparing them in groups, but without recognition of similarity. Some faulting does occur at Sand river in the cliffs, but it is not detected on the brooks inland and the disturbances have every appearance of being very local and of but slight geological importance. There is also no such change in the character of the deposit as a fault of the required magnitude would be expected to exhibit. In fact there is less change noticeable there than at other portions of the shore where there are no disturbances of any kind. For instance at Birch cove, a buttress, of the sandstones, stands out from the general line of the cliffs and being of a different colour, appears, when viewed at a distance, as a piece of faulted ground. The change from the general gray colour of the series to a reddish hue between vertical lines is absolutely without any faulting or break in the bedding planes.

Reasonable
conclusion.

No other conclusion than that reached by Mr. Fletcher seems reasonable after his very careful survey and repeated stratigraphical comparisons of the several theoretical divisions of this unrivalled section of the Carboniferous rocks: and that not only does the whole distance from Mill creek to Shulee represent an unbroken ascending series but that thence onward the upper beds are continued without serious faulting to Spicer cove, where the formation ends in a heavy bed of red conglomerate resting on the volcanic rocks of the Cobequid ranges.

No unconformity.

It is interesting to find that here no unconformity has been detected although a distinct separation in the Carboniferous sequence does occur elsewhere, as at New Glasgow,* and as at Hard Ledge, Maringouin, where an overlap is clearly exposed. There the nearly horizontal upper strata are seen to rest on moderately inclined Millstone-grit rocks, and at the contact fragments of the latter are included in the former. This exposure is at a place where a drift was at one time driven in on a bed of black fire-clay for coal, and it is near a well-

* Annual Report, Geol. Surv., Can., 1890-91, Vol. v, (N.S.) pp. 109 P., Trans. N.S. Instit. Sc., 1893, pp. 272-3.

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marked syncline in the Millstone-grit that has its axis dipping 15° towards the west and in the direction of Shepody bay.

For a further comparison of strata on the New Brunswick shore the bay was crossed to Alma, and the cliff section towards Owls head and the great fault there so prominent were examined. These gray rocks there offer an end view of the strip of Millstone-grit that rests on the flanks of the Pre-Cambrian coastal range and continues from Alma to Shepody mountain, forming without doubt an extensive outlier of the lower members of the Millstone-grit rocks exposed in more continuous series on Maringouin, and thus belonging to a horizon much below that of the workable coal seams of the Joggins.

With Mr. Fletcher, Dorchester cape was visited. Here occurs a transition from an extensive series of arenaceous shales and sandstones, of a reddish colour, into an equally well exposed series of the lower members of those gray of colour, which are assumed to be the base of the Millstone-grit. Here they include some beds of dark fire-clay and shale, with a few inches of coal, upon which openings have been made. No encouragement was, or could be given to the prospectors there at work, that further labour might lead to a material improvement in the thickness of the coal. A similar opinion had to be expressed in answer to inquiries respecting the thick shale beds carrying a few inches of coal at Slack cove, on the point of Maringouin. Here, large scales of fish were found in the under clay of the coal.

In this search for conditions similar to those associated with the Cumberland coal-field, it was noted that there were repetitions, though on a much reduced scale, of the basin north eastward alongside the prolongation of the coastal range, at the head of the Bay of Fundy; the first and smaller, lying between the pink rocks of Maringouin and Dorchester cape, and the other and larger, to the east of Westcock, where the base of the gray series is upheaved. In this basin, the greatest body of Carboniferous measures is in the neighbourhood of Sackville, and here, under the 'Permian' overlap, the highest beds of the series to be found in New Brunswick, are probably to be located. There is, however, no reason to expect that the highest will reach the horizon of the Joggins seams.

In company with Dr. Ells, the contact of the gray series with the overlying 'Permian,' was sought for, and what was considered an unconformity, could be made out at several points. One of these is seen near the Westcock watering tank, on the Intercolonial railway. It also appeared that the line of contact assumed on the map of 1885,

might be somewhat modified, and the 'Permian' made to include the gray sandstone area about Gaspereau river, and thence, on, to Cape Tormentine, and also to run further inland, so as to include strata to the head of Shediac bay. In the other direction, south of Baie Verte, it should include the gray rocks of Halls hill towards Joliceur, but the ridge from Mount Whatley to Aulac, should, as shown, remain Millstone-grit.

At Coal branch, near Harcourt, referred to in 1901, by Prof. Bailey, a considerable sum was expended in sinking a shaft of large size, to find a seam of coal, said to be six feet thick, and to have been struck in a bore-hole. The shaft cut only the 16-inch coal, mined in the adjoining river bank.

Search for
petroleum.

The New Brunswick Petroleum Company have continued a vigorous search for oil, near St. Joseph's college and across to the Petitcodiac river, and the mouth of Weldons creek; some 14 holes have been bored, and oil got in several of them. Some of these holes have been put down to depths of over 1,000 feet. All are in the Albert shales, though in some cases, they were started in the gray sandstone, which in places caps the older strata. Several of the holes are coupled in series, and fitted with pumps and tanks. In the fall, three rigs were in operation at the same time, in the strip of Albert shales intruding between the Petitcodiac and Memramcook rivers.

Albertite.

At the Albert mine, Mr. Robinson exposed, east of a fault, a branch of the original Albert vein, as much as two feet in thickness, and of sufficient importance to warrant further exploration, as the 'coal' will bring at least \$14 a ton for varnish making.

Late in the fall another bore-hole, No. 8, was put down by Mr. John White, at a distance of 500 feet from No. 5, and at a depth of 177 feet some 20 inches of coal was found. In this hole a double core barrel was used, and the section obtained was as follows:

Section.

Journal of No. 8 Bore-hole at Dunsinane.

1902.	Ft.	In.
Oct. 23, blue clay.....	10	0
" red marl.	7	0
" and sandstone.....	19	0
" sandstone, mixed, light and red (mottled?)	5	0
" " with red marl.	15	0
" blue hard rock.....	4	0
" red marl.....	3	0
Oct. 31, " with sandstone.....	19	0
Nov. 1, bluish fine hard	3	0
" blue shale.....	3	0

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1602.	Ft.	In.
Nov. 1, red marl and sandstone.	22	0
" red and blue sandstone, with a little gray shale..	8	0
" red and blue hard marl.....	10	0
" blue, fine hard rock.....	6	0
" red and blue mixed marl.....	5	0
" blue, fine stone.....	9	0
" red marl.....	7	0
" red and blue sandstone.	8	0
Nov. 17, dark blue shale.....	1	0
" blue shale.	9	6
Nov. 19, coal.	1	8
" shale.....	0	8
" coal.....	0	4
" shale.....	0	10
" hard rock.....	0	8
" shale.....	0	5
" fire-clay.....	0	3
" coal.....	0	4
	5	2
" hard pavement	2	0
" blue shale.....	14	0
" sandstone.....	15	0
" blue shale.	2	0
" sandstone and conglomerate	53	0
" shale.....	3	0
" sandstone and conglomerate	77	0
	344	8

On comparing this journal with that kept, in other terms, of bore-hole No. 1 a similarity is noticeable and there seems to be a strong probability that they relate to the same strata down to the coal bed. Similarity of sections.

For the sake of comparison, the section of coal and associated strata struck in No. 5 bore-hole may here be given. This hole was bored without a double core barrel, and at 135 feet gave the following record in descending order:—

Coal.....	20 inches.
Light coloured soft shale	18 "
Coal.	6 "
Soft shale	9 "
Dark shale	3 "
Black shale.	6 "
Gray shale	6 "
Sandstone..	18 "

The seam met with in these bore-holes is not regarded locally as the same coal as that opened at White's mine on the brook side, although the record of the borings seems to correlate fairly well with that kept of the deep No. 1 hole.

The map of 1885 shows the Intercolonial railway, at Calhoun's mills on the Memramcook river, as cutting through a granite boss about a Granite bosses.

mile in length. This is overlaid on its northern and eastern sides by sandstone beds of an horizon somewhat above that of the gray conglomerate which is so prominent a feature at Dorchester, the copper mine and the Bay shore. Another similar boss, but smaller in size, was this year observed on the brook near the head of McManus's mill-dam, four miles to the south-east of the larger exposure. Resting also on it on the eastern side were similar gray sandstones without intervening conglomerates or members of the red series. Against it on the south are highly inclined beds which at one time were included among the Lower Carboniferous. At the granite boss by the brook side was a small mound of highly altered very coarse conglomerate of uncertain age, and a larger exposure of the same rock occurs a mile further towards East Memramcook, here protruding through the superficial till. This larger mound, or its concealed extension evidently supplied the numerous boulders with which the neighbourhood is strewn.

GEOLOGICAL OBSERVATIONS IN NORTHERN NEW BRUNSWICK.

Professor L. W. Bailey.

Tobique and
Nipisiguit
rivers.

Dr. Bell's instructions to me were to the effect that an examination should be made during the months of August and September, of the region about the headwaters of the Tobique and Nipisiguit rivers, the object of such exploration being threefold, viz., first, to add to our knowledge of the topography of a tract as yet only imperfectly known or mapped, secondly, to obtain any additional information available bearing upon the geological age and structure of the same region; and lastly, to make a special examination of certain tracts included therein with reference to their supposed auriferous character.

All necessary arrangements having been made for a two months' stay in the field, the latter was entered upon by way of the Tobique river, early in August, the party consisting of myself, Mr. R. A. A. Johnston, of the Geological Survey staff, whose assistance in many directions I would here gratefully acknowledge, and two guides familiar with the country.

Routes
followed.

Owing to the state of the water, as well as for other reasons, it was thought best to at once ascend by canoes to Nictor lake, at the head of the Little Tobique river, and, after a portage to the Nipisiguit, to descend that stream at least as far as the mouth of Silver brook, the latter having been referred to as traversing a part of the district in which the finding of gold had been reported. Upon reaching this stream, after only a cursory examination of the country traversed *en*

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route, an attempt was made to ascend it with a view to panning operations on the materials of its bed, but these, consisting almost solely of large blocks of felsite and granite, with little or no fine sediment, proved so unpromising, while the difficulties of the ascent, owing to the density of the vegetation bordering and in part covering the small stream, were so great, that all hope of effective work of this character was soon abandoned. A similar attempt was also made upon the Little South Branch, which joins the Nipisiguit about one mile and a quarter below the mouth of Silver brook, but with the same result. The immediate vicinity of the Nipisiguit, having been thus found to be altogether unfavourable to prospecting operations, our attention was at once turned to the other two objects of our journey, it being our intention, later in the season, to reach the sources of the stream mentioned above by the way of the other or Serpentine branch of the Tobique, it having been understood that in the latter direction, the conditions for the search of gold were more favourable.

In entering upon the study of the topography and geology of the Nipisiguit country, as well as on that of the Tobique, we found ourselves greatly assisted by the work previously done, especially in the former direction, by Prof. W. F. Ganong during the last few years. The results of this work are embodied in a series of articles contributed to and published by the New Brunswick Natural History Society, and include, besides the first instrumental survey of Nictor lake, the fixing of the position of the more prominent hills and hill ranges along the entire length of the Nipisiguit, the determination of the altitude of many of them, and the assignment to them, according to a definite system, of distinctive names, by which, it is hoped, they may in future be known.

Professor
Ganong's
work.

Not thinking it desirable to lose time by attempting to duplicate what had already been well done, our attention so far as topography was concerned, was mainly directed to the actual measurement of some of the hills of which the altitude had been only estimated by Prof. Ganong. Among these may be mentioned, in particular, the eminences designated as Mount Charnisay, Mount Wightman and Mount Walker, the last two having, respectively, the elevation of 630 feet, and 900 feet above the river, at their base.*

Heights of
hills.

In connection with the topographical observations, some interesting geological facts were at the same time noted.

* These results have not been corrected for air temperature, and are only approximate. If 900 feet be added as representing the probable level of the river at this point (Ganong gives 875 feet for the mouth of Portage brook), these numbers become respectively 1,530 feet, and 1,800 feet above sea level.

Previous
work in this
region.

Without entering here into a detailed review of work previously undertaken in this region, it may be observed that in the Report of Progress for 1879-80, the tract of land traversed by the Upper Nipisiguit, together with a very large area lying on either side of that stream, was described as being probably of Pre-Cambrian age, and was so represented in the map-sheet issued some years later (1887) as illustrative of the geology of the northern highlands of New Brunswick. In each case the rocks were described as consisting mainly of crystalline felsites, sometimes becoming syenitic by admixture of hornblende, and in places associated with gneisses, feldspathic and other schists, supposed to be of equivalent age with resembling rocks in the southern counties of the province. The view referred to was generally accepted, and seemed to be confirmed by the observations of later explorers, including Dr. R. Chalmers, Mr. W. McInnes and Prof. Ganong, neither one of whom seems to have observed anything inconsistent therewith. It was also shared by the writer, who, as early as 1864, made a traverse of the Tobique and Nipisiguit rivers, and described their more obvious features, though without attempting to assign to any particular age, the felsites which are such a predominant feature in the hills about the sources of these streams. Yet the facts observed by us during the past summer, not only upon the occurrences noted above but at many other points, are such as to suggest the possibility of a somewhat different view being entertained as relates to portions at least of the area under review.

New interpretation
suggested.

The first facts bearing upon this possible new interpretation, were observed upon the summit of Mount Wightman, situated nearly opposite the mouth of the Little South Branch, and seventy-one miles above the town of Bathurst, where the felsites, instead of possessing the uniform and highly crystalline character usually associated with Pre-Cambrian terranes, were found rather to present the character of rhyolites and feldspar porphyries, associated with conglomerate felsites and breccias, which closely recall some members of the felsitic series which in the Geological Survey report for 1870-71, were included in the Silurian system, as found around the shores of Passamaquoddy bay, especially above the towns of Eastport and St. Andrews. Like the latter they are also often markedly epidotic and in places coarsely amygdaloidal, containing, in addition to blotches of chlorite and calcite, blebs resembling pebbles of white quartz, in the form of miniature geodes lined with minute quartz crystals. It is true that similar features distinguish many areas of so-called Huronian rocks in the southern counties, but they are there associated with chloritic, hornblende and hydro-mica schists and slate conglomerates, usually highly

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coloured, none of which have been observed by us in the hills of the Upper Nipisiguit. Another interesting feature, is the fact that upon Mount Wightman the possibly sedimentary nature of the felsite beds is indicated by the occurrence of strongly defined colour bands (usually reddish in a gray rock) and in such a position as to show that the strata are not far from horizontal. This being the case, it is not to be wondered at that these felsites should spread widely, that they should be essentially alike over large areas, and that in connection with the debris with which all the hillsides are deeply strewn, they should hide from view any beds of a different character upon which they may rest. Thus all the high hills lying between Nipisiguit lake and the Portage stream, a distance of fourteen miles, would seem to be thus constituted, and it is certainly the case with Mounts Charnisay, La Tour, Wightman and Walker, except that the latter is in part composed also of bright red syenite, which is probably intrusive. So the eastern end of the Green range and the so-called Feldspar mountains show associations of reddish and gray feldspar-porphry with imperfect syenites. But that a rock of a different character does underlie a part, if not the whole of the felsitic area, is possibly indicated by facts observed in the ascent of Bathurst mountain on the Peak of Teneriffe, an eminence lying between the two ranges last mentioned and which from its prominence is familiar to all travellers upon the Nipisiguit.

Strata nearly horizontal.

Bathurst mountain.

The hill last named which attains, according to the observations of Prof. Ganong, an elevation of 2,108 feet above sea-level, is remarkable for its concealed form, the steepness of its ascent, and the small area which crowns its summit. It has always been supposed to consist, with the hills around it, of felsite only, and one might readily make its ascent and reach no other conclusion. Yet at certain points upon its slopes are to be seen exposures which show that this view is open to question. These exposures are to be found in ravines along the eastern side of the eminence at an elevation equal to about one-third of the entire height of the hill, and instead of felsite consist of heavy beds of coarse conglomerate and sandstone, dipping north-westerly at an angle of 40°. It was thought at first that there might be remnants of a newer and unconformable formation lying protected in a basin of older rock, but closer examination showed that not only are they covered by felsitic beds but that they clearly alternate with the latter. Thus we have here further indications that the rocks of the region are apparently bedded, that they lie at comparatively low angles, and that in addition to volcanic and semi-volcanic materials they include others of distinctly aqueous clastic origin. Moreover, these latter are wholly unlike any Pre-Cambrian rocks to be seen else-

Possibly not all felsite.

Conglomer-
ates.

No fossils
found.

where in New Brunswick, and in many respects they closely resemble some of the sedimentary beds forming characteristic members of the Silurian system. In particular, the conglomerates, which like the sandstones are of a gray colour, more or less blackened with manganic oxide, while consisting largely of pebbles of white quartz, have associated with these, fragments of black silicious slate or petrosilex, just as do the conglomerates which occur near the base of the Silurian system in the valley of the Beccaguinec river in Carleton county or along the Aroostook river in the State of Maine. The sandstones also find their counterpart in closely resembling beds in each of these localities as they do upon the Seigas river in Victoria county, in these latter cases carrying typical Silurian fossils. We were not fortunate enough, in the limited time at our disposal, to find organic remains in the sandstones of Mt. Teneriffe, and in their absence it would be premature to predicate anything too positively as to their age but unless our observations, which were necessarily limited, are incorrect, they suggest, as already stated, for the structure of the region a different view from that previously entertained, and must be considered as an important factor in any further exploration of the region.

Probably lie
at a low angle.

A key to the supposed structure having been obtained as applicable to the upper Nipisiguit country, the idea was at once suggested that a similar structure might prevail elsewhere, and especially about the sources of the Tobique river. To test this point, an examination was first made of Bald or Sagamook mountain, almost the highest eminence in New Brunswick, which overlooks Nictor lake at the head of the Little Tobique. Here again felsite rocks, as first described by the writer in 1864, constitute the conspicuous parts of the mountain, especially near its summit, and until recently were believed to constitute its entire mass, except that, as observed by Dr. Ells and recently by myself, there are, at the base of the hill, towards its eastern end, ledges of greenish-gray chloritic and felspathic schists and slate conglomerates. These have been described as being nearly vertical and as dipping away from the felsites of the mountain; but though it is by no means easy to determine their true attitude, I am disposed to think that they are lying at a low rather than a high angle, and that the latter appearance is really due to their strongly pronounced cleavage. This view derives some confirmation from the fact that at the eastern end of the mountain, overlooking the Nipisiguit portage, the lower half of the eminence was found by Mr. Johnston to consist of slates and the upper portion of felsites, the latter showing distinct bedding at a low angle, and again by what is seen upon the opposite shore. Here, as well as upon Visitor island, the same slaty

rocks, which are largely slate conglomerates, are again well exposed, and give the same appearance of highly tilted strata, but in ascending Mt. Gordon, at the base of which they lie, repeated alternations of greenish chloritic schists, schistose grits and slate conglomerates occur in attitudes which indicate but little inclination. Finally, towards the western end of Nictor lake, near Armstrong brook, the shores previously represented as of Silurian slates, show ledges of felsitic rock, varying from gray to reddish in colour, and with a distinct dip of only 5°. Thus the sedimentary nature of the beds around the lake, the intimate association of felsitic or rhyolitic aqueous deposits, and the generally low inclination of the strata, accord with the observations made upon the Nipisiguit, and go far to indicate that like relations exist in the intermediate district and far beyond the latter.

Felsite at
Nictor lake.

It had been my intention, while at Nictor lake, to examine in detail all the hills in its neighbourhood, including Mounts Bailey, Franquelin and Bernardine, as well as the somewhat more remote eminences, such as Mounts Head and Carleton (the latter the highest mountain in New Brunswick), but a very serious accident having happened to one of our guides, making it necessary to seek surgical aid, this undertaking had, for the time, to be abandoned. Subsequently, all efforts to obtain another competent guide in the place of the one disabled having proved fruitless, all further work for the season was abandoned, by Dr. Bell's direction.

Accident to
guide.

Owing to the circumstances alluded to, no examinations were made of the Right Hand branch and its tributaries, nor of the area between these and the Nipisiguit, drained by Silver brook and the Little South branch of the river last named. I am, therefore, unable to add anything upon the subject of the auriferous character of this district to what has been said by Dr. Chalmers and by myself in previous reports, except to state that so far as regards the region actually examined by us, including the felsitic hills and their associated rocks, no facts were observed which would favour the idea that these contain gold, or indeed any metal in workable quantities. Quartz veins are of rare occurrence, and such as were observed seemed to be quite destitute of mineral contents. The beds of the streams examined also, consisting almost solely of large blocks of felsite or syenite, offered but little encouragement to the prospector. It may be added that in all these respects the region of Nictor lake and the sources of the Nipisiguit is somewhat strongly contrasted with that of the Serpentine, where the rocks are mainly schists or slates, and abound in quartz veins. The extension of these latter beds would probably cross the upper part of Silver brook on the Nipisiguit and, therefore, include the area whose

Occurrence
of gold not
probable.

supposed auriferous character was an important factor in determining the investigations detailed in this report. But this and many other important questions relating to the northern highlands must await, as they should certainly receive, further careful study.

Growth of
forest.

In addition to the above summary I have only to say that, in accordance with Dr. Bell's instructions the obtaining of data bearing upon the rate of the growth of trees in areas previously deforested was kept constantly in mind, but little could be learned, mainly for the reason that over the larger part of the region visited by us the forests are still in virgin condition. In the settlement of St. Almo, however, upon the Tobique, which was fire-swept about thirty years ago, and where the growth destroyed consisted of white birch, spruce and poplar, with many pines, the trees are now mostly white birch, attaining a size of four to ten inches in the butt, with spruce from twelve to thirteen inches, but with little or no pine. In some instances* a period of twenty-eight years has brought a tract covered only with a low scrubby growth of spruce to a condition capable of being cut to advantage. Some tracts, on the other hand, seem incapable of restoration, or only of a very slow one, the growth apparently as a result of the nature of the soil or the abundance of boulders being at all times low and scrubby.

SURVEYS AND EXPLORATIONS IN RICHMOND, CAPE BRETON, KINGS, CUMBERLAND AND OTHER COUNTIES OF NOVA SCOTIA.

Mr. Hugh Fletcher.

Winter office-
work.

Mr. Fletcher spent the winter of 1901-02 in the ordinary routine work of the office, including correspondence and the compilation of plans and sections from surveys made in the field by himself and his assistants, during the previous summer, as detailed in the Summary Report for 1901 pages 208 to 214.

He left Ottawa on April 15 for Cape Breton to examine borings made at Coal brook in the Richmond coal-field near the line of the new railway from the Strait of Canso to St. Peters and Louisburg. He returned on May 1, but left again for Nova Scotia on June 16, with Mr. A. T. McKinnon, and did not return until January 2, 1903.

Field work
of a general
character.

Owing to the activity in various mining districts of the province and the demand for geological information of use in certain explora-

* The tract specially referred to is that of the head of the Mamozekel, one of the tributaries of Tobique river.

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tions and mining operations, much of Mr. Fletcher's time was spent, by Dr. Bell's instructions, in Cape Breton and elsewhere outside the field of his systematic work.

The borings at Coal brook were made by one of the provincial government calyx drills, in charge of Major James L. Phinney, of Wilmot, Nova Scotia.

It is stated on page 118 of Part P. of the Report for 1879-80, on the authority of Mr. A. McBean, that two seams of coal occur at Coal brook. Extensive explorations made since that date seem, however, to prove rather that the coal seam opened and worked near the mouth of the brook is the same as that found higher up and that it lies in a narrow basin, parallel to the general course of the brook, along which black shales are well exposed. From the workings near the mouth, from which eighty tons of coal are said to have been shipped, the seam was traced 700 feet, opened again about 1,600 feet further up stream, and followed thence nearly 1,000 feet further. The first drill-hole, about half a mile from the shore and on the top of the bank, is on the north side of the narrow basin, the second was bored at the axis of this basin, where the beds lie nearly horizontal, about 800 feet downstream on the left bank. The first was bored to a depth of 520 feet through blackish and gray argillaceous and arenaceous shales, with several thin coaly layers, light gray or whitish micaceous, pyritous sandstone, often striped, usually fine but with coarse beds. Only one thin red band was cut, about six feet in thickness. The dip of the rocks was 20° near the top while deeper in the hole it steepened to 49°.

Boring for coal in Richmond coal-field.

Bore-holes.

The second hole, drilled to a depth of 1,020 feet, must have proved the strata for a considerable distance toward Doyle creek. As stated above, only one workable seam of coal was found in these holes. Its thickness is variable. The maximum where uncovered in the brook was three feet two inches, with a two inch parting about six inches from the top, the upper part of the coal being impure. Where cut in the second bore-hole at 170 feet, the coal was one foot eight inches thick, corresponding with the seam as opened in a long trench to obtain fuel for the engine and in a level, 168 feet long, opened by McBean above the first bore-hole. The floor is a dark-gray, fine, coherent sandstone; the roof and overlying rocks are similar. Two other seams of coal, six and four inches thick respectively, were also cut in the deeper hole, as well as a band of red shale six or eight feet thick. The proportion of the core lost in drilling was very small. Some of the light-coloured shales carry *Asterophyllites*, *Cordaites* and other plants, and certain layers consist of a mass of fossil shells beautifully exposed in a cross section.

Thickness of coal.

Explorations
at Little river
mine.

The red cores taken from a boring immediately north of the mine at Little river indicate either that red strata overlie the coal seams there or that a fault intervenes between the bore-hole and the workings. The latter supposition is that adopted in the map of 1884. On the railway, east of the Buchanan road, a belt of red shale appears to underlie the dark shales on the north side of the basin mentioned above, or along the fault shown on sheet No. 21. Eastward along the railway, dark shales have been cut, but no red strata, and near Shannon lake there are good exposures of gray sandstone like that of the shore south-east of Coal brook. Above the railway bridge over White brook, greenish and gray and drab argillaceous shales and fine sandy flags are succeeded by reddish sandstone, more or less argillaceous, striped or banded, with a nearly vertical northerly dip, an attitude found among similar red rocks in the Falls brook to the westward. From the deep shaft at Rory McDonald's, red shale, like that of Hawkesbury, was thrown out.

Evans island.

On Evans island, search has been made in the gray, blackish and rusty argillaceous shales, many of which contain nodules of ironstone and small seams of coal not far from outcrops of gypsum, as at Little river. Mining has also been resumed at Seacoal Bay (Port Malcolm) mines in the Richmond coal-field.*

Bore-hole
for coal at
Glendale.

Early in the autumn the calyx drill was removed from Coal brook to Glendale to test the rocks which lie beneath the coal seam described in the section on page 99f of the Report for 1879-80, near which several thousand dollars had been spent in prospecting. In that report it was stated that 'the quantity of available coal in the basin even if the seam were much larger, would be extremely small,' but the possible existence of other seams was also suggested. A bore-hole was put down to a depth of 500 feet, chiefly in gray and reddish argillaceous shales: but no other seams were found. It was begun at the foot of a steep bank of black shale overlying the coal seam. Down River Inhabitants nearer the bridge, borings were also made by Mr. James McDonald, M.P.P. and others, in which coal was found, but apparently not in workable quantity.

At Port Hood
mines.

Later in the season, the drill was taken to make trial of the number and thickness of the coal seams in the Port Hood basin, and two holes were bored in the strata underlying the main seam without, however, cutting any other workable seam.

Deep boring
north of New
Glasgow.

The Pictou Exploration Company is using another of the government calyx drills, which has a capacity of 3,000 feet, to test the

* Report for 1879-80, Part v. page 121.

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measures underlying the New Glasgow conglomerate on the west side of the East river Pictou, below Trenton. The drill was placed in Rear brook, where a plentiful supply of fresh water is available, and the rock is in situ with nearly horizontal bedding. Transportation to the spot was convenient, and repairs of all kinds can be readily made in New Glasgow; so that, although the depth to be bored here in order to pass through the whole thickness of the conglomerate and overlying rocks may be somewhat greater than at the mouth of Begg brook, on the Middle river, another site suggested, this advantage may be compensated by those mentioned above and also by the strong probability that being nearer the large seams of the Pictou coal-field south of the North fault, these seams may have an extension in workable form towards this bore-hole, which must in any case be a deep one. It has been put down already to a depth of nearly 600 feet, or about 200 feet into the conglomerate.

In the same county at Foxbrook, south of the coal measures of Westville, a hole has been bored nearly 400 feet, with one of the smaller diamond drills belonging to the provincial government, chiefly through red sandstone and shale coloured as probably Lower Carboniferous on sheet No. 47 of the Nova Scotia series of geological maps.

Foxbrook and
Hantsport
boreholes.

By the enterprise of a few citizens of Hantsport a hole has been bored 1,300 feet with a third government calyx drill, in charge of Mr. Clarence Smith, of that town. The site chosen is in a brook near the boundary between the counties of Hants and Kings, half a mile west of the railway station, at a point where search had previously been made for coal. Gray sandstones and shales of the Horton series, known elsewhere to contain important quantities of albertite, rich bituminous shale and petroleum, lie in the brook with a low northerly dip. To a depth of about 300 feet the drill cut chiefly light and dark gray fine sandstone, underlaid by bluish gray coherent argillaceous shale, containing a few plants and bands of ironstone, to 800 feet, below which gray sandstone prevails. Some of the shales are said to have yielded the characteristic odor of petroleum. At 150 feet a strong feeder of water was struck.

Boring for oil
at Cheverie.

On Cheverie brook, boring for oil has been begun with a cable drill; and it is hoped that a thorough test will be made of this district, the promise of which was pointed out by Professor H. Y. Hind, of Windsor, more than thirty years ago. In a report on the petroleum indications at Cheverie, Professor Hind stated that although 'feeble external indications are not generally sufficient of themselves to warrant an immediate expenditure of capital, especially in a region where natural petroleum springs are not known to exist at the present time,' yet

Bore-holes at
Lake Ainslie
and Skye
Glen.

that 'the evidences of the existence of petroleum at Cheverie are sufficiently strong to warrant the expenditure of capital in a systematic exploration by means of bore-holes.' Oil and bitumen have been found in cavities, joints and fissures of a mass of gypsum, largely quarried in this neighbourhood, which overlies a great body of black shales containing numerous remains of plants and animals and thus 'supplying the material for the supposed source from which petroleum has originated.' The age of these shales is that of oil-producing strata of other countries, the structure of the rocks seems 'favourable to the accumulation and preservation of petroleum,' and there is, consequently, presumptive evidence that deep boring might reach stores of petroleum. 'Exploratory bore-holes can alone decide whether these stores have been exhausted at Cheverie by long continued overflow,' and the cost of such bore-holes should not be very great. Wells have been bored in the oil district of Lake Ainslie, in Cape Breton, *3,260 feet and to a much greater depth at Gaspé, in search of oil. Explorations were made last summer at Skye Glen, one well having reached a depth of more than 1,100 feet, but without success.

Manganese
and limestone
at Walton.

In this connection a cursory examination was made of the district between Walton and Noel, in which bands of the dark slates and flags of Split Rock and Cheverie also occur, the overlying sandstones and shales being also found near Cheverie. Succeeding these Devonian rocks at the manganese mines west of Walton is a reddish flaggy limestone or marble, overlaid by gray massive limestone. In and near the limestone occur ores of manganese and other metals (¹) and it seems probable that, as the demand for limestone leads to the quarrying of these beds along the contact, bodies of these ores will be discovered, as large as any that has been mined, without the expense and uncertainty that at present attends their extraction.

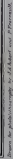
In continuation of the bore-holes put down by the Hon. David MacKeen along the outcrop of the Tracy seam (²) a diamond drill hole was bored by Mr. Cottrell, to a depth, it is said, of more than 300 feet, near Murdoch McLean's. Halfway between Cochran lake and Macdonald lake (sheet No. 135), in a slope from which coal was taken last winter for local consumption, the seam is said to have measured four feet five inches. It is hoped that these explorations will be extended further to the westward.

*Report of Progress Geol. Surv., Can., 1882-84, Part II, page 90, and Annual Report, vol. X. (N.S.), page 102A.

¹Jour. Can. Mining Inst., vol. I., p. 227.

²Sum. Rep., Geol. Surv. Can., 1901, p. 208.





of part of

CUMBERLAND COUNTY, N.S.

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HUGH FLETCHER D.A.

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The Mullins seam also was exploited in a shaft near Senator MacKeen's bore-hole at Lynk lake, where it is stated to be four feet and a half thick, instead of three feet as in the section given of the bore-hole (³). On the Mullins seam.

A visit was also made to recent developments by Mr. C. A. Meissner for the Dominion Steel Company, among the crystalline limestones of Eskasoni (⁴) in the immediate neighbourhood of the interesting exposures of Cambrian fossiliferous rocks studied by Dr. G. F. Matthew (⁵). Although the developments failed to discover limestone suitable to supplement that at present obtained in large quantity for the furnaces from the Marble mountain of West bay (⁶) yet they afforded interesting contacts with the surrounding felsitic, gneissic and syenitic rocks.

I also visited Middle river, in which several Chinamen have been washing for gold and Mr. Scranton has erected a small crusher and is still mining the quartz veins of the Second Gold brook (⁷). His trenches and pits have exposed several veins from four feet downward and into one of these he has driven a long tunnel on the line of strike of the inclosing slates. In the quartz there are fine samples of gold resembling that found in the sand of the brook, finely spattered throughout the veinstone or in leafy layers in the joints. Gold of Middle river.

During a portion of the months of July and August, I was with Mr. H. S. Poole and Dr. R. W. Ells at some of the more important Carboniferous sections on the Nova Scotia and New Brunswick shores of Cumberland basin and Chignecto bay (⁸) to compare the different series of Carboniferous rocks with those of the well-known section at the Joggins. The difference between the lowest beds of this section and those called Permo-Carboniferous is well seen on Minudie point, where the latter consist of gray, blackish and red coarse glistening sandstone, with a few bands of red argillaceous shale, pebbly patches and friable conglomerate, like the Permo-Carboniferous of other districts, but also like certain beds below the Millstone-grit at Downing cove. Examinations on Cumberland basin.

³ Sum. Rep. Geol. Surv. Can., 1901, page 269.

⁴ Report of Progress Geol. Surv. Can., 1876-77, pp. 411, 427, 436.

⁵ Sum. Rep. for 1901, p. 225 and Matthew's Report on the Cambrian of Cape Breton. (Just out.)

⁶ Report of Progress Geol. Surv. Can., 1877-78, pp. 29 to 32r.

⁷ Annual Report Geol. Surv. Can., 1882-84 (N.S.), part II., pp. 29 and 97; Professor Woodman's report to the N. S. Department of Mines, 1898, page 12.

⁸ Sum. Rep. Geol. Surv. Can. 1902, p. —.

Line of bor-
holes near
Mapleton.

In extension of the borings of 1901 westward from Leamington towards Mapleton, ⁽⁹⁾ sixty-six holes, seventy-two feet deep and under, were bored on a line following the south side of Rattling brook for about two and a half miles to Hoeg brook, along a belt of gray argillaceous shale and sandstone overlaid by red shale and sandstone, the whole series apparently overlying the coal seam passed through near the top of the 715 feet bore-hole at Mapleton. ⁽¹⁰⁾ The gray strata resemble in texture and composition those below the coal measures of the south branch of Black river, but on that section, as elsewhere stated, no red rocks appear. Moreover, no fault has been detected that could separate these rocks from the coal measures to the north-eastward, and the tracing of the small coal seam eastward from the Mapleton bore-hole has made its identity with the Barlow seam, more than ever probable. In any case it is important that this region should be thoroughly explored, since, even if these are lower measures, we might expect that, with their north-westerly dip, they would be overlaid somewhere by strata containing workable seams of coal.

Barlow seam.

Upper
Maccan river.

The Upper Maccan river, below Captain Mills, seems to follow a flat anticline, the dips being at a very low angle. In adjoining brooks, which enter from the north below Hoeg brook and near the Etter road, the opposite dips of another anticline are well defined in a gray sandstone full of fossil plants. Above these brooks the river bank shows more than fifty feet of red argillaceous shale, probably that found by bore-holes far to the eastward of Hoeg brook.

In Henry brook, red rocks, precisely like the latter but probably much lower, have a low northerly dip, are interstratified with gray fine sandstone, and are succeeded to the southward by gray sandstones and shales containing rootlets. At and above the fork, coarse grit and conglomerate occupy the brook.

Coal probably
traced to
Hoeg brook.

The strike of the small coal seam at the deep Mapleton bore-hole would, if produced, carry it to Hoeg brook near the road. Here also a quantity of drifted coal was found in the brook near Mr. Willard Gilroy's house. Two boreholes put down hereabout found apparently the two bands of red shale and sandstone that underlie at no great depth the coal seam, which must in this event outcrop a short distance north of the road. As already stated, this coal is probably the equivalent of the highest seam in the section of Coal Mine brook, and it therefore becomes a question of great commercial as well as scientific

⁹ Sum. Rep., Geol. Surv. Can. for 1901, p. 214.

¹⁰ The cost of and time occupied in this boring are given in the report of the Depart. Mines for Nova Scotia, 1874 page 26.

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interest to determine what has become of the underlying workable seams of the latter section and their relation to the conglomerate along the northern slope of the Cobequid hills at Rodney, Mapleton, Southampton, Newville, and Apple river, as well as to that which underlies the coal at the Chignecto mine on the north side of the basin which may be in part or wholly its equivalent.

Relation of coal measures to conglomerate of the Cobequid hills.

Between Mapleton and East Mapleton, a thickness of about 2,500 feet would seem to include all the strata underlying the bore-hole seam to the Pre-Carboniferous granite of the hills. Of this thickness 715 feet cut in the borehole are of fine texture and associated with thin coaly layers. Would this hole if continued have touched the conglomerate of the hills south of Upper Maccan river? Does this latter represent coal measures or other fine sediments at a distance from the hills? Or has a fault or unconformity north of it escaped observation? A glance at the accompanying map will serve to illustrate these questions.

It has been pointed out that on the north side of the syncline which has its axis near the shore at Shulie there are exposed about 1,500 feet of carboniferous strata, while from the same axis southward less than 5,000 feet appear, chiefly coarse sediments which may represent only the upper part of the section on the north side. Mr. John Rutherford in 1870 suggested the probability * that near Apple river, workable seams may lie at a considerable depth from the surface. On the shore section, as on that from East Mapleton to the Springhill coal mines, no great fault has been observed; and the geological structure as now understood seems to justify the boring of one or more deep holes in the hope of determining whether the workable coals are cut off by faulting, replaced by barren strata along this line, or concealed by unconformity or overlap, and can yet be reached and mined.

Possibility of reaching workable coals by deep boring.

Work has been vigorously prosecuted at the Springhill mines, and a smaller yield of coal obtained from the Joggins, Jubilee, Stratheona, Chignecto and other mines on the north side of the Cumberland coal basin. The Chignecto colliery has been reopened by the Maritime Mining Co. and the slope sunk to a depth of 825 feet.

Coal mines.

In my investigations I have been again greatly assisted by the kindness of Mr. J. R. Cowans, the gentlemen mentioned on page 214 of last year's Summary Report, Messrs. J. A. Johnson, J. G. Rutherford, David Mitchell, James Baird, G. B. Mills, and others.

Acknowledgements.

* Trans. North of England Inst. M.E., vol. XIX, page 117.

Copper ore of
Cumberland
county.

Some time was spent in an attempt to define more closely the boundaries of the various subdivisions of the great mass of carboniferous sediments lying between Maccan and Tatamagouche rivers, in the area covered by sheets 59, 60, 61 and 62 of the Nova Scotia series of geological maps. These strata include the copper ores of Chisholm and Canfield creeks, the Palmer and Chisholm mines and other workings in the Wallace, Philip and Pugwash rivers, which have yielded no adequate return for a very large expenditure of money during the last ten years; the unimportant outcrops of coal at Roslin Hill, South Victoria, Conn's mills, Malagash point, Oxford junction and other places; the gypsum and selenite of Plaster cove, Saltsprings and River Philip; and the celebrated gray sandstone of the Wallace quarries. As these examinations are still unfinished, the results will not at present be referred to. The difficulty of distinguishing the gray sandstone of the Upper Carboniferous of Ragged reef from the Millstone-grit sandstone of the Lower Cove quarries, the Lower Carboniferous red shales and sandstones of Downing cove from the Upper Carboniferous of McCarron cove, and other groups on the Joggins section, gives some idea of the difficulties encountered when these rocks are traced inland towards Athol, Mapleton and points farther east, where exposures are not so good and large portions of fine sediment are replaced by coarse grit and conglomerate.

Copper ores.

The mode of occurrence and the character of the copper ore of the district have been sufficiently described in the Annual Report for 1889-91, part P., page 186. It is in the form of nodules and films of chalcosite usually in dark-gray and blackish more or less carbonaceous beds.

The Lower Carboniferous marls near the mouth of Pugwash river are used as a source of supply for the brickworks; and the adjoining beds of limestone have been extensively quarried.

Brookfield
iron mine.

With Mr. F. H. Chambers, the manager, a visit was paid to the Brookfield iron mine, the ore from which is shipped over a short tramway to the Intercolonial railway for use at the Ferrona furnaces. From this deposit, described in the Annual Report for 1889-91, part P., page 177, as near the contact of Devonian and Carboniferous rocks, 20,000 tons of excellent limonite are said to have been extracted. The ore is near the surface, overlying Lower Carboniferous rocks having been eroded, but in the immediate vicinity is a gray limestone of this formation, so that some of the hollows or basins separated by protrusions of Devonian strata seem worthy of being tested.

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My assistants, Messrs. M. H. McLeod and A. T. McKinnon, in Kings and Annapolis counties surveyed the district westward from Salmon-tail and Gaspereau lakes, for sheets Nos. 98 and 99, their south line running from Salmon-tail lake to the Nictaux river and being in granite as far as Allan lake. North of the granite lie Cambrian and Silurian slates and quartzites which are in contact with soft, crumbly sandstone of Triassic age, along the foot of the South mountain. This sandstone, deeply eroded in the valley of the Cornwallis and Annapolis rivers, rises to the summit of the North mountain where it is cut off by basaltic trap. The section is thus similar to that between Gaspereau river and North mountain, described in the Summary Report for 1901, page 211 and illustrated by an accompanying map. The district joins that described in the Summary Report for 1894 and again, by Professor L. W. Bailey, in Vol. IX, Part M. In its western portion lie the iron mines of Torbrook and Nictaux.

Surveys by
McLeod and
McKinnon in
Kings and
Annapolis.

The roads were surveyed with odometer, the brooks and lakes chiefly by pacing between the roads. From September 25 to October 4, Mr. McKinnon collected minerals in Cumberland county to be used for educational collections; he obtained two barrels and a half of fibrous gypsum at Clarke head * and two and barrels a half of agate at Two Islands, packed the specimens and forwarded them to Dr. Bell at Ottawa.

Minerals for
collections.

Except in the western part, there are few minerals of economic value, but the district is well adapted to agriculture and fruit growing. Besides the apples, plums, pears and other fruits for which the region is noted, the culture of the cranberry has for some years afforded a profitable means of utilizing the bog lands of the Annapolis valley between Kentville and Middleton and has become one of its most important industries. The large Aylesford bog and other flats in which the water can be drained to about a foot beneath the surface, after the removal of the peat or turf, are extensively used for this purpose. The mud is ploughed, harrowed, mixed with the underlying or transported sand, and planted with vines in shallow furrows about two feet apart. Woods, bushes and grass have then to be kept in check until the vines get matted over the ground and are ready to yield, after which, with a little judicious care, fifty barrels or more to the acre may be gathered for many years, although there may be seasons in which the crop is shortened or even destroyed by frosts in June and September, before the berry has attained its full size, or the berry-worm may cause the fruit to fall off or rot before it is fit to pick.

District
adapted to
agriculture
and fruit
growing.

* Dawson's Acadian Geology, page 105.

8.000 feet. In many parts of the district the rocks are heavily covered with red sand and gravel, but along the banks of the streams they are frequently exposed. On the South river, above the mill at the road west of Morristown, blackish and dark-gray flags, containing much pyrite and some mica, resembling the rocks of the Black river of Gaspereau above Whiterock, are cut like them, by masses of greenish granular diorite, and belong, no doubt, to the upper or clay-slate group of the gold-bearing series. At and above the fork of this river, the slates are foliated and gneissic, interstratified with layers of spotted or andalusite-schist, broken through by masses of red coarse granite: and gray gneiss and granite occupy the eastern branch for some distance until succeeded by granite.

Red and green slates. A short distance below the mill, blackish slates are succeeded by greenish slates, like those of Canaan, cut by intrusive dykes of greenish and gray crystalline diorite. Below Factorydale, the greenish slates give place to red and green mottled slates, overlaid by bright-red slates: but none of the quartzites of Whiterock appear on this section.

Dykes. Westward through Harmony and at a school-house and hall, blocks indicate apparently a great dyke of greenish crystalline and compact diorite. On the slope of the hill, just before coming to the Fales river, there is a fine outcrop of light-coloured compact and granular diorite and felsite. Above the bridge on this river, greenish and mottled slates, like those which yield *Dictyonema* at Canaan, becomes very porcellaneous where in contact with masses of diorite. Down the river they are less altered, and beyond them come red and green mottled slates, showing fine dendritic markings like those of the brooks of Gaspereau, Highbury and Canaan. On the right bank, between these red slates and the bridge above, a tunnel has been driven into black graphitic slates which occupy a narrow belt about a quarter of a mile below the bridge: and about thirty yards farther upstream is the quartzite of Whiterock, Canaan and Highbury, whitish or spotted with red, tilted at a high angle.

Whiterock quartzite.

Similar red shales and quartzites cross the road to the westward. Near the Annapolis county line, on Messenger brook, the first stream east of East Torbrook post office, there are diorite dykes cutting red and blackish slates, which dip northward, include many beds of quartzite and are overlaid by gray and blackish shales and argillaceous sandstones, full of shells, encrinurites and corals. These are similar to the slates near the mouth of the Black river of Gaspereau in which markings of plants were found in 1901; they are also like the slates of Deep Hollow, near Port Williams station, from which were obtained

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joints of crinoids. At the top of this section, just before it is concealed by the intervalle, to be overlaid next by Triassic sandstone, red and greenish slates, well exposed at the foot of a gorge, contain fossils at first mistaken for *Dictyonema Websteri*, but determined by Dr. Ami as probably a new species of *Tenestella* in the same beds with numerous Silurian fossils of species enumerated by Professor L. W. Bailey in his report on the geology of south-west Nova Scotia.*

On the east side of the brook is the Messenger mine, containing a six-foot bed of hematite, that was mined to a depth of ninety feet, the ore being similar to that of Torbrook.†

NOVA SCOTIA GOLD FIELDS.

Mr. E. Rodolphe Faribault.

Mr. E. R. Faribault was engaged during the winter 1901-1902 in plotting the surveys made the previous summer in the counties of Halifax and Lunenburg, Nova Scotia, referred to in the Summary Report for 1901, pages 214 to 221. Office work by Mr. Faribault.

The plans of the gold districts of South Uniacke, Montague and Lake Catcha, surveyed in 1899, and completed up to date and the plan of Tangier, surveyed in 1898, have been published. Plans of gold district published.

The plan of the gold district of Gold river, surveyed the previous summer, was also completed, but its publication has been deferred in the hope of getting more data in the field to work out its structure more satisfactorily. A further examination of the district was consequently made last summer, and although the structure is still incomplete at certain points, it is thought better to have the plan published immediately, as it will be useful to mine owners who are contemplating new developments.

Mr. Owen O'Sullivan has made good progress in the compilation of the one-mile to an inch map upon which he was engaged last winter. The compilation extends now as far west as the line of the Inter-colonial railway between Elmsdale and Bedford, and from the road leading from the latter place to St. Margaret bay, it extends south- Publication of maps.

* Annual Report Geol. Surv. Can., vol. IX, (N.S.) part M., pages 94 to 97.

† Acadian Geology, pp. 563 and 571; Supplement, 1891, page 20.

ward to the shore of the Atlantic. It is expected that the following map-sheets will be ready for publication before leaving for the field :

No. 53, Lawrencetown sheet.

No. 54, Musquodoboit Harbour sheet.

No. 55, Middle Musquodoboit sheet.

While the compilation of the following sheets will be nearly completed :

No. 66, Elmsdale sheet.

" 67, Waverley "

" 68, Halifax City "

" 69, Prospect "

Map of
Halifax and
vicinity.

The Halifax City sheet will be especially interesting and useful, and it is deemed advisable to issue, for local purposes, a special map of the *city of Halifax and vicinity*, on the same scale, but larger than the ordinary 12 x 18 inches size, with the city as a centre and including Bedford, Waverley, Montague, Cow Bay, Herring Cove and the *et cetera*; to the east and west of the city for some twelve miles.

Field work.

On the field work accomplished in the Nova Scotia gold-fields during the past season, Mr. Faribault reports as follows :—

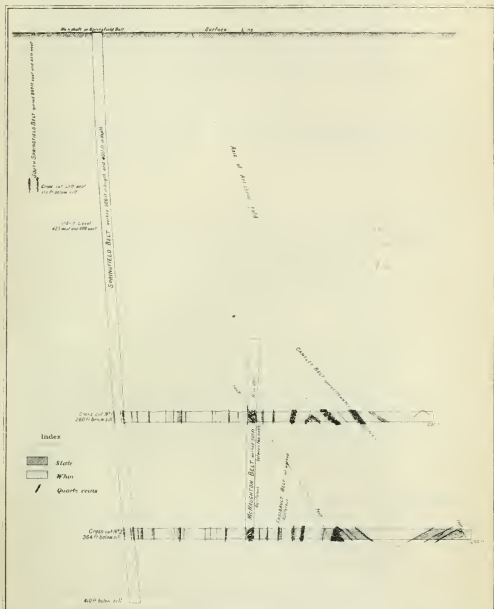
In accordance with your instructions, I left Ottawa on June 7, for Nova Scotia to resume last season's surveys in connection with the mapping of the Lower Cambrian gold-bearing series of Nova Scotia and to continue the study of the structure of the gold mining districts of the province.

Acknowledgments.

In the performance of my field-work, I have received much information and assistance from miners and other persons, and I wish to offer especially my acknowledgments to Dr. E. Gilpin, inspector of mines ; Dr. M. Murphy, provincial engineer ; Sheriff Donald Archibald, and Messrs. James H. Austin, Crown Lands Department ; Harry Piers, curator provincial museum ; Henry S. Poole, F. H. Masson, Rufus O. Bayer, Joseph H. Austen and Fred. P. Ronnan of Halifax ; G. J. Partington, A. B. Cox, W. F. Fancy, John McMillan, Chas. D. Maze and Stephen M. Giffin of Isaacs Harbour ; Howard Richardson, Frank Sweet and S. R. Giffin, of Goldboro ; S. R. Heakes and Matthew McGrath, of Wine Harbour ; Arthur G. McNaughton and Wm. McIntosh, Goldenville ; George W. Stuart, Truro ; A. Kent Archibald, Monroe Archibald and John Worrall, of Harrigan Cove ; George Fraser and Laughlin McLean, of Fifteen-mile Stream ; Hon. James D. McGregor and Thomas Cantley, of New Glasgow ; E. Percy Brown, Dr. D. Stewart, C. W. Crowe, T. H. White, C.E., and V. J. Paton, of

Geological Survey of Canada

ROBERT BELL, Sc D. (Canrab), M D., LL.D., FR S., ACTING DIRECTOR.
1900.



Surveyed by E. R. Fordham, B.S.S.

TRANSVERSE VERTICAL SECTION
Through Main Shaft and Cross cuts
BLUENOSE GOLD MINE.
GOLDBEVILLE, NOVA-SCOTIA

To accompany Part A, Vol. XX.

No. 806

Scale of Feet
0 10 20 30 40 50 60 70 80 90 100

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Bridgewater ; J. A. Crease and T. R. Prince, of Mount Uniacke Mines ; S. G. Lyman, Renfrew ; Charles Thompson, Elnsdale ; Levi Dimock, West River Sheet Harbour ; L. W. Getchell, Caribou Mines ; Robert Kaulbach, Middle Musquodoboit ; Charles Keddy, Lake Ramsay, New Ross ; Dr. Henry W. Cane, New Ross ; Prof. G. T. Kennedy and Dr. H. Y. Hind, of Windsor, N.S.; and H. K. Wicksteed, C.E., Mahone Bay, N.S.; also Marland L. Pratt, Boston, Mass. and Paul M. Curtis, Harvard University, Boston, Mass.

I was again ably assisted, during the whole season, by Messrs. Archibald Cameron and J. McG. Cruickshank, who worked in the field until November 19, when they began the plotting of their surveys, which is now completed. Assistant's work.

Surveys in Lunenburg County.

Mr. Cameron was engaged the greater part of the season on a survey of that part of the county of Lunenburg which lies west of La Have river and adjoins the counties of Queens and Annapolis. Lunenburg county,

Mr. Cruickshank assisted me until August 11, in surveying gold districts in the counties of Guysborough and Halifax ; then he joined Mr. Cameron in Lunenburg county.

The region surveyed measures 12 miles east and west and 30 miles north and south, or about 360 square miles. It is drained by the western tributaries of La Have river, the Petite Rivière and the head-waters of the Pleasant and Port Medway rivers, and an innumerable number of small lakes and streams. The country is generally well settled, mostly by people of German descent, particularly along the coast and valleys of La Have and Petite Rivière. It includes the town of Bridgewater on La Have river and the gold districts of Leipsigate, Voglers Cove and Pleasant River Barrens.

The region is underlaid entirely by the gold-bearing series, folded into parallel upheavals and depressions running northeast and southwest. The strata are less tilted than in the eastern portion of the province, the rocks seldom dipping at higher angles than 45 or 60 degrees. A few of the upheavals have the form of broad elliptical domes, less favourable to the development of interbedded auriferous veins than the sharper anticlinal folds further east. Important auriferous fissure-veins, cutting the strata at acute angles, appear, however, to be more numerous, and those operated at Leipsigate and Voglers Cove have already produced good values. Gold-bearing series.

Denudation has also been much less extensive : as a result, the white rocks of the lower division of the gold-bearing series have not been brought up so extensively to the surface as to the eastward of Halifax, and the slates of the upper division predominate over larger areas.

Structure. The structure of the rocks of this region has not yet been worked out in such detail as to determine exactly the anticlines and synclines and the cross faults. A few preliminary notes may, however, be given here on the position of the main anticlines.

Seven anticlines. Seven anticlines and synclines have been recognized across the forty miles of country stretching between the outside islands off Dublin shore and the northern limit of the county, at an average distance of about six miles apart.

The seven anticlines are met with in the following order from south to north.

1. *La Have anticline* : The most southerly anticline cropping out at the surface is well exposed on Hartland bay where it crosses Pointe Enragée and Goff point and running westerly across the entrance of La Have river, shows on La Have islands, beyond which it passes under the sea.

2. The Ovens anticline : This crops out on Green island, at the entrance of Mahone bay, and extending westerly between East Point and Big Duck islands, it runs through the Ovens mine, Rose bay and Five houses, crosses the mouth of La Have river, skirts Dublin shore and runs through Green bay into the sea.

Gold washing at the Ovens. At the Ovens washings have often been made of the sands and gravels detached by the action of the sea from auriferous quartz veins intercalated in slate on the arch-core of the anticlinal fold.

3. *Indian Path and Voglers Cove anticline* : This begins at the south end of Aspotogan peninsula, where it occurs immediately south of New harbour and Herring cove, and extending westerly through Mahone bay, it skirts along the north side of South East cove on Big Tancook island, crosses Beckman island at its north end and Lunenburg harbour about one mile south of the town and passes through Indian Path mine ; thence, running more south-westerly, it crosses La Have river at the Horne brook and runs through New Cumberland, Crousetown, Voglers Cove mine and Port Medway.

Indian Path mine. At Indian Path, a few main leads were developed and a crusher built several years ago, but they have not been worked to any extent.

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At Voglers cove, a very promising fissure-vein cutting across the stratification has recently been operated and found rich in gold; and a few interbedded veins have also been prospected. ^{Voglers cove mine.}

4. *Leipsigate and Gold River anticline*: From the town of Mahone Bay, this anticline runs westward, passes the north end of Coveys lake and through the town of Bridgewater on La Have river, to the west of which it develops, through Hebbs and Leipsigate lakes, into a broad dome, formed by its intersection with another anticline coming from the north-east through Maitland forks, Vaughan lake and Gold River gold district.

A hurried examination was made of the gold district of Leipsigate and the following notes may be given, subject to revision. ^{Leipsigate gold district.}

The district is situated on the south-western and sharper portion of the dome where an important fissure-vein has been traced for about 6,000 feet in length through four or five different properties, three of which were successfully operated last summer. The vein dips north 70° at the surface and flattens to 55° at the depth of 200 feet, while the strata dip south 50° . The outcrop of the vein describes a long curve almost parallel with the strata; at the German mine it runs easterly across the strata towards the south at a slight angle; further east, at the Micmac mine, it is about parallel with them and at the eastern extremity it curves to the north and crosses the same strata towards the anticline. Consequently the intersection of the vein with the strata pitches eastward at the west end and westward at the eastern end and becomes horizontal between the two. Several pay-chutes already developed seem to occur along the intersections of the vein with certain belts of dark-gray slate favourable to the deposition of gold, hence they should be well defined, of great length (6,000 feet) and should recur underneath one another in depth. The laws governing the occurrence of pay-chutes on the fissure-veins mined at Brookfield, Caribou, Cow Bay, Oldham and Voglers Cove, appear to be the same as those observed at Leipsigate, and they should be well studied to ensure extensive and successful development. At the western end of the district several interbedded veins have also been discovered on the north and south dip, but still remain undeveloped.

5. *Caribou Lake anticline*: This anticline is well exposed at New Cornwall on Caribou lake, on the eastern side of which it is cut off by granite. From Caribou lake it runs south-westerly to the head of Big Mushamush lake and through Sucker lake to the foot of Wentzel lake on La Have river; thence it passes at La Have Branch and runs through Crooks, Wollenhaupt and Prescott lakes.

6. *Pleasant River Barrens anticline*: Begins at the granite on Eisenhower lake, Newburn, runs south-westerly to the north of West and Rocky lakes and through the head of Church lake, and crossing La Have river one mile below Indian brook, it runs through Maders, Kaulback, Hirtles and Rhyno lakes of the West Branch of La Have, and crosses the Barrens and Upper Shingle lake of Pleasant river, where the fold develops into a very broad dome.

Pleasant
River Barrens
gold district.

Several promising, gold-bearing, interbedded veins have been developed on the north-east and south-east portions of the dome in the so-called gold district of Pleasant River Barrens, and rich ore has lately been developed, but no important mining operations have yet been undertaken on any of the leads discovered.

7. *Ohio River anticline*: The most northerly anticline has not yet been well determined, as the surveys are not completed. It occurs a short distance north of Hirtles stillwater on the head-waters of the North Branch of La Have river and crosses the Ohio river about three miles north of the New Germany and Pleasant river main road. At Mosers Corner and Meisners Settlement it is cut by a southern expansion of the main granite mass which underlies the region to the north.

Several cross-country faults have disturbed the continuity of these seven upheavals, but more detailed work is required to locate them.

Gold Districts Surveyed.

Gold districts
surveyed.

My own work in the field was confined chiefly to a closer study of the structure of several gold-mining districts in the counties of Guysborough and Halifax. The first part of the summer until the 11th of August, was spent in making detailed surveys of the gold districts of Isaacs Harbour, Cochran Hill and Wine Harbour in Guysborough county and of Harrigan Cove and Beaver Dam in Halifax county, with a view to preparing special large scale plans of these districts. The surveys were for the most part plotted in the field and the plans will be completed for publication this winter.

Some preliminary notes may be here given on these districts, relating to the character of the auriferous veins already worked and their intimate relation to the structure of the anticlinal upheavals, with some conclusions on the zones of special enrichment and the possibility of developing a succession of new workable veins, similar to those mined at Bendigo, Australia, to a depth of 4,000 feet.

Isaacs Harbour Gold District.

The provincial department of mines has grouped under the name of Isaacs Harbour gold district, Stormont District, the gold districts of Isaacs Harbour, Richardson (Upper Seal Harbour), Country Harbour Narrows and Forest Hill, spread over a tract 75 square miles in extent. Of these, Isaacs Harbour has been the most worked. It is situated on Isaacs Harbour, on the Atlantic coast at a distance of 50 miles to the south of Antigonish, a station on the Intercolonial railway, and it extends westward to Country Harbour and eastward to Seal Harbour.

Three weeks were spent making a special plan of the gold district of Isaacs Harbour, on the scale of 500 feet to an inch and it has since been completed. It covers an area of two miles and a half long by one mile and a third wide, extending on the east side of the harbour from Victoria mine to Bettys cove and on the west side from Peter Sinclair's hotel to Ragged point.

The plan comprises all the auriferous veins discovered on both sides of the harbour. On the eastern side of the harbour it includes the Victoria, Goldfinch, Mulgrave, Skunk-den, Hurricane Point and Dung Cove mines, and on the western side, the North Star and Burke mines. It does not comprise, however, the Richardson and Doliver Mountain mines, now extensively worked, which are situated two miles and a half farther north on the Upper Seal Harbour anticline crossing Isaacs harbour at its head, a special plan of which was published in 1897.

The rocks underlying the area covered by the plan are the quartzose-sandstones, called 'whin,' and interstratified slates forming the lower division of the Lower Cambrian gold-bearing series of Nova Scotia.

These rocks have been plicated into three main anticlinal folds running parallel in an easterly and westerly direction across Isaacs harbour. They have been called the north, middle and south anticlines of Isaacs harbour. Three anticlines.

All the veins discovered in the district are interbedded veins formed during the process of folding along the stratification planes on the arch-core or limbs of these three anticlinal folds.

The original structure of the folds has been much disturbed transversely by a great dislocation coming from the north-west and following the North-west Branch brook to the head of the harbour, as shown on the published plan of Upper Seal Harbour. From the head of Faults.

the harbour it runs S. 15° E. (magnetic) and passes between Hurricane Point and the eastern shore and through Webb cove and Dung Cove, giving a horizontal, left-hand throw of some 1,200 feet to the north on each of the three anticlines. Several minor faults have also been determined, branching off in a north-easterly direction from the main harbour fault.

Doliver
Mountain
fault.

Recent developments, made by Mr. G. J. Partington on the Doliver Mountain property, have proved that one of these faults is farther east than indicated on the published plan of Upper Seal Harbour gold district. It has a horizontal throw of some 400 feet and follows, very probably, the course of the Davidson brook, in a south-westerly direction, to the harbour where it joins the main harbour fault.

The three upheavals are best observed along the western shore of Isaacs harbour, where a continuous section of the strata is well exposed from Holly point to Ragged point.

North anti-
cline North
Star mine.

Isaacs Harbour north anticline.—This anticline is well defined at the North Star mine where mining developments show the Grant, Saddle, Little Saddle, McPherson and Burke leads to curve inside and underneath one another on the arch-core of the anticlinal fold and pitch to the west at an angle of 18° from the horizon. On the north leg, the strata dip north at angles increasing gradually, from 45° on the Grant and Burke leads to 75° at Holly point: while on the south leg the dip increases abruptly to 75°, flattens again and curves in the synclinal fold of the North Star lead, 120 feet south of the anticline.

In depth, the axis-plane of the folds dips about vertically.

Hurricane
Point mine.

The course of the anticline is N. 56° W. (magnetic), and that of the syncline is N. 59° W., the folds converging eastward under the harbour; and, at Hurricane point, they are only 12 feet apart and form a crumple very favourable to the development of rich auriferous veins conformable with the strata, one of which, the Hurricane Point lead, crops out at the surface and has already been much worked and yielded handsomely. Immediately east of Hurricane point, the crumple is cut off by the main harbour fault and thrown north some 1,200 feet; it shows on the eastern shore where it develops rich rolls on the Mulgrave leads.

Rich saddle-
veins.

It is noteworthy, that all the veins cropping at the surface along this crumple have proved rich, although sometimes too small to be worked profitably. The North Star lead has been mined on the western pitch of the north limb of the synclinal fold to a depth of 492 feet,

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while the others were worked on the western pitch of the anticlinal fold, viz: the Saddle lead 180 feet, the McPherson lead 120 feet, the Burke lead 258 feet, while the Hurricane Point, the North Mulgrave and the Mulgrave leads have been mined respectively 430, 400 and 2,200 feet in length and 160, 190 and 220 feet in depth.

The mining developments at the surface show that the paying portions of the veins are of great length and well defined, and that they are confined to the crumple, along which they form a rich zone which has been proved to extend from the North Star lead to the Mulgrave, a length of about one mile and a quarter. Deep mining.

In depth, the zone of special enrichment extends likewise along the nearly vertical axis-plane of the fold and form a succession of rich superimposed crumples and rolls to great depth.

No mining has yet been undertaken to develop this succession of crumples and rolls in depth. Encouraged by information received from this department, the Hurricane Point company made an attempt, two years ago, to develop a crumpling underneath the one they had already worked so successfully on the Hurricane Point lead, but at the depth of 170 feet operations were, unfortunately, discontinued just as the crumple was being reached and the vein was improving in size and value. Vertical shaft.

All the facts show conclusively that this anticlinal and synclinal system of pay-chutes offers a great field for deep mining by means of vertical shafts. Thus a vertical shaft sunk on the anticline near the Burke lead would probably cut a succession of superimposed saddle-veins of payable values, and cross-cuts driven 100 feet south at different levels would develop inverted, auriferous saddle-veins, on the synclinal fold, pitching west 18° and outcropping eastward under the harbour. The Hurricane Point lead would be cut at the approximate depth of 650 feet. Likewise, a vertical shaft sunk on the anticline at Hurricane point would cut a succession of crumples similar to and probably as rich as that mined by the Hurricane Point Company. Mulgrave mine.

On the east side of the harbour a very rich pay-chute or roll, pitching westerly under an angle of 12° , was extensively worked on the Mulgrave lead for a length of 1,200 feet and a maximum depth of 210 feet. This pay-chute is undoubtedly the eastern extension of one of the superimposed rolls of the Hurricane Point flexure thrown this far north by the harbour fault.

The axis-plane of the flexure runs here horizontally S. 58° E. and dips about vertically, while the interstratified veins run S. 63° E. and

dip north 62° . Large rolls of auriferous quartz were formed along the intersection of the veins with the axis-plane of the flexure, pitching westerly 12° . The rich roll worked on the Mulgrave lead is one of these and it should extend westerly beyond the actual workings to the harbour fault and be succeeded vertically by other rolls underneath one another on the veins outcropping to the south of the Mulgrave lead. This system of rolls offers great possibilities for deep mining if properly developed. It can be best developed by means of a vertical shaft and cross-cuts, or by sinking a shaft on the Mulgrave lead, below the pay-chute already worked and cross-cutting south at different levels.

Victoria mine.

At the Victoria mine, on the eastern shore of the harbour and 1,500 feet to the north of the Mulgrave, a roll of auriferous quartz, reported to be ten feet thick and pitching east 35° , has been worked for some 200 feet in length and 105 feet deep. At the Goldfinch mine, 2,100 feet to the south-east of the Victoria mine and 1,380 feet to the north of the Mulgrave lead, a roll of paying quartz, 12 inches thick and pitching east 15° , was mined 300 feet in length and 90 feet deep. It is remarkable that these two rolls, as well as the auriferous drift found on the shore to the north-west of the Victoria and 1,500 feet to the south-east of the Goldfinch mine, are all situated along the same line, running S. $59\frac{1}{2}^{\circ}$ E. and parallel with the Mulgrave line of pay-rolls, but with the difference that on the latter the rolls pitch westward. As the strata strike S. 65° E., the Victoria-Goldfinch line of rolls intersects them at a slight angle, and probably forms a succession of auriferous rolls occurring on certain belts towards the south-east which might prove productive if developed.

Goldfinch mine.

Fault.

A left-hand fault was located on lot 18, block 2, eastern division. It runs down the Dung Cove brook S. 37° W. to the salt water pond, where it intersects the main harbour fault, and gives a horizontal throw of 130 feet north on the Mulgrave lead and about 250 feet on the Mundic lead which corresponds to the Skunk-den lead.

Undeveloped veins.

The rich float found to the east of this fault and south of the Mulgrave lead is derived undoubtedly from rolls formed on the Bliss, Slate or other leads at their intersection with the eastern extension of the flexure, and developments should therefore be undertaken in this direction.

Middle anticline.

Middle anticline.—The middle anticline could not be located as well as the north, because the rocks are concealed and developments have not yet been sufficient along its course.

On the western side of the harbour it occurs 500 feet south of the lighthouse, where it is concealed by a sand beach and salt water pond,

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and it extends westerly to Country harbour, covered by drift showing debris of gold-bearing quartz.

It runs easterly across the harbour into Sculpin cove, immediately north of Salmon rock, and extends to the main harbour fault, where it is thrown north some 1,200 feet; beyond this, it runs south of east, 550 feet south of the Barry lead, to the Dung Cove brook fault, where it is thrown north 250 feet, and resumes its course towards the head of Crane pond on Bettys brook.

This fold is broad, both limbs dipping at angles increasing gradually to 65° on the north and 55° on the south. The developments have not yet been sufficient to determine the zones of special enrichment, but rich float found along its course proves the occurrence of payable veins. The structure of the fold shows that a zone of such veins will probably be found on both limbs, but at some distance from the axis, where the angle of dip is over 50°.

The only important leads developed are situated 700 feet north of the axis, at the Skunk-den mine, where a pay-chute dipping east 18° was worked on the Mundic lead for a length of 700 feet and a depth of 120 feet. A large block of rich quartz was discovered immediately south of the Mundic lead, but the vein from which it came has not yet been discovered.

On the east side of the main harbour-fault and about 1,100 feet south of the middle anticline, a rich belt of leads, called Hattie belt, 21 feet wide, was worked many years ago, by open-cut on the Gisborne property for a length of 360 feet and a depth of 110 feet and more recently on the Griffin property, and it was uncovered eastward beyond a 50-foot fault for 1,400 feet. The leads are conformable with the strata and dip south 55° to the depth of 110 feet, where they curve rapidly and the quartz pinches out in a synclinal fold, to the south of which the strata are shown in a cross-cut to dip north at a low angle with little or no quartz. The quartz was reported exceedingly rich on the north limb of the synclinal trough.

Rich veins
along syn-
clinal fold.

Very rich float was found to the south of this belt and a great deal of prospecting was done by David Buckley and others to locate the veins, but without success. Doubtless the float comes from another rich vein in the synclinal trough, superimposed to and to the south of the Hattie belt. Likewise, the rich drift found on Red head is derived probably from the north limb of the synclinal fold, thrown this far south by the main harbour fault, possibly in the vicinity of the McMillan and other belts of lead cut along Sand cove. This is one of

Red Head
gold drift.

the few instances in which rich veins have been observed to occur in a synclinal fold in Nova Scotia, but in Bendigo, Australia, such veins have been mined in a few cases.

To develop these synclinal veins successfully vertical shafts might be sunk along the axis of the trough. A succession of superimposed V-shape veins would thus be cut through which should be especially rich on the south dip.

South
anticline.

South anticline.—The Isaacs harbour south anticline is well exposed at Ragged or Bear Trap point, and for about one mile farther west along the shore of Country harbour, where a few cross-veins have been observed. On the eastern side of the harbour, it passes at the south end or a little to the south of Red head, and some of the auriferous debris washed in from the sea may possibly come from veins situated on this fold, if not from the above mentioned synclinal fold.

East of Dung cove, the anticline is thrown north about 1,000 feet by the main harbour-fault, and it crosses the road at a sharp turn where David Buckley has developed a flat lead dipping north and south on the apex of the fold. Its extension eastward is heavily covered with drift. Auriferous drift and a few veins are reported to have been discovered at Bettys cove, to the south of this anticline.

Seal Harbour
rich drift.

A great deal of prospecting has been done two miles east of Isaacs harbour, along a line of extraordinary rich drift, running south $2\frac{1}{2}^{\circ}$ east towards the eastern side of Crook cove. It is believed that the drift comes from the intersection of a cross-country vein with certain belts or interbedded veins which are especially well mineralized and are possibly the eastern extension of some anticlinal system of veins.

The total production of the Stormont district given in the official returns of the Provincial department of mines from 1862 to 1901 inclusive, is 245,409 tons crushed, yielded 78,750 ounces, valued at \$1,496,266, average yield per ton \$6.10. Of this, probably one half and the richest ore was produced by the Isaacs Harbour mines, the Richardson mine having mostly given low grade ore.

Every mine in the Isaacs Harbour district is now abandoned, but important developments are in contemplation.

Cochran Hill Gold District.

Cochran Hill
anticline.

The gold district of Cochran Hill is situated in Guysborough county, on the east side of St. Marys river, ten miles north of the town of Sherbrooke and thirty miles south of Antigonish, by the coach road.

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One week was spent surveying the structure of the formation and a plan has since been prepared on the scale of 500 feet to an inch, which is now ready for publication. It includes Crows Nest and Cochran Hill mines which are nearly two miles apart on the same anticlinal fold.

This fold is the sharpest one known in the province and is much inverted to the south, the north limb dipping north 60° while the south limb is overturned and dips north 75° . The axis-plane of the fold should thus dip northerly at an angle of 68° .

The general course of the anticline at the surface is S. $82^\circ 45'$ E. (magnetic) and it pitches west at an angle of about 15° or 20° .

At the Crows Nest mine the anticline was located at a bluff of rock situated immediately east of the mine's road, and half-way between the mill and the manager's house, on area 916, block 75. It was traced eastward, up a steep cliff, across Cochran hill and the main coach road, to Cochran Hill mine, where it passes at the south corner of the quartz-mill and is well exposed 400 feet further on area 486, block 77.

The rocks brought up by the upheaval are the quartzose-sandstones and slates of the lower division of the gold-bearing series. The rocks have been subjected to such great pressure that they have become highly schistose and crystalline, holding fine crystals of staurolite, andalusite, garnet and mica. The cleavage is highly developed, while the bedding plane is almost completely obliterated, and, consequently, the structure of the anticlinal fold is very difficult to make out.

All the gold-bearing veins operated at both mines follow the stratification plane. A few quartz veins holding mica are also met with, especially at the Crows Nest mine, but they generally follow the cleavage plane and invariably cut the bedded veins when they meet. Quartz mined from one of these at the Crows Nest mine is reported to have yielded a little gold, but it is more likely that the gold came from the encasing slate belt which holds also an auriferous vein—the Belt lead. These micaceous veins are offshoots from granitic dykes occurring in the vicinity and of later origin than the auriferous bedded veins.

At the Crows Nest mine, the Stake, Rose and Belt leads have been worked by different companies, and more recently by the Old Provincial Mining company, for a maximum length of 850 feet and a depth of 100 feet. These leads occur within a width of 60 feet and at an average distance of 200 feet to the south of the anticline.

Cochran Hill
mine.

At the Cochran Hill mine a large belt of leads, called the Mitchell belt, and a few other adjacent leads, have been mined from time to time. They are situated at a distance of 300 feet to the south of the anticline. The maximum depth attained is 125 feet on the Ross lead and surface developments have been extended over 1,800 feet in length.

The Mitchell belt is 75 feet wide and contains interbedded veins from two to twelve inches wide. It is considered a low grade deposit which could be operated profitably.

Zone of auriferous
veins.

The present developments indicate that the relative position of the gold-bearing leads with reference to the anticline is the same at both mines; that the zone of auriferous veins runs nearly parallel with the anticline, at a distance of 200 feet at Crows Nest mine and 300 feet at Cochran Hill mine to the south of the axis, and that systematic developments along this zone between the two mines will probably uncover new gold-bearing veins.

In depth, the pay-chutes dip westerly, parallel with the pitch of the fold, and they probably also recur on the different adjacent veins, towards the north, in a plane parallel with the axis-plane of the fold which dips north at an angle of 68° . Developments and cross-cuts have therefore to be directed towards the north as greater depth is attained.

The rich pay-chutes worked at the Crows Nest mine, on the Stake and Belt leads pitch westerly at an angle of 15° to 20° . Both streaks have been worked out to a fault running south easterly, beyond which they have not been discovered. To find their continuation on the west side of the fault, the extent of the downthrow and horizontal-throw of the fault has to be established. Unfortunately, this could not be exactly determined from the developements made along the fault. The location of the anticline on both sides of the fault shows that it has been thrown to the left for about 50 or 75 feet. The horizontal throw of the leads is probably about the same.

A 20-stamp mill with one Wilfey table has recently been built by the Old Provincial Mining company at the Crows Nest mine, and, at the Cochran Hill mine a 20-stamp mill with two Wilfey tables was newly put in.

In the official returns of the Department of Mines for 1901, the total production of Cochran Hill is incorporated with that of Golden-ville, under the title of Sherbrooke district: 264,131 tons of ore crushed yielded 148,477 ounces of gold, valued at \$2,821,068, average yield per ton \$10.68.

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Wine Harbour Gold District.

The gold district of Wine Harbour is situated in Guysborough county, on the Atlantic coast, 16 miles south of the town of Sherbrooke and 56 miles from Antigonish. Wine Har-
bour gold
district.

Three weeks were spent in surveying the district and plotting a plan on the scale of 400 feet to one inch, to include the whole area under development, two miles long by three-quarters of a mile wide.

The area is underlaid by the quartzose-sandstones, or 'whin,' and the slates of the lower division of the Lower Cambrian gold-bearing series of Nova Scotia.

The measures have been flexed into two anticlinal and one intervening synclinal folds converging towards the west.

The most northerly anticline has been determined on lot 388, block 6, immediately south of Rocky point on Indian harbour, where the rocks dip at low angles increasing gradually, northward to 75° at Fleming cliff, and southward to 45°. It runs N. 74° W. and converges westward with the synclinal, the two joining at a point about 900 feet north of the Major Norton workings, where the strata are exposed laying almost horizontal near the dome of the southern anticlinal fold. A few veins were observed along the shore, 800 feet north of Rocky Point, but none have so far been developed on this fold. North
anticline.

The synclinal trough occurs between the two anticlines. From the northern extremity of Barachois pond, it runs westerly, passes 150 feet to the north of the old site of Eureka mill, and ends at its junction with the north anticline. Syncline.

On area 140, block 6, a belt of promising quartz rolls in slate was uncovered in the synclinal trough, which pitches eastward at a low angle, and others probably occur along its course which might prove productive if developed.

The south anticline crosses the south end of Barachois pond, runs westerly N. 65° W. under the boulder clay of Rude hill, passes 100 feet south of the old site of Eureka mill, follows Barachois brook and outcrops at the surface on area 36, block 41, at a distance of 750 feet north of the Major Norton workings, beyond which it is heavily covered with drift and runs westward N. 63° W., passing a short distance north of the Smelt Brook cove of Wine harbour and at the south end of Lake Cooper where it is well exposed. Wine Har-
bour anticline.

The south anticline may be considered the main anticline of the district, while the other anticline and the syncline form a subordinate crumple on the north limb of the former.

The north limb on the Wine Harbour anticlinal fold dips north 50° or 60° , while on the south limb the dip increases abruptly to 70° , then gradually to 85° . It pitches easterly at a low angle diminishing towards the west and it forms a dome at the western end of the district which could not be exactly determined as the rocks are concealed.

No leads have yet been discovered on the north limb. All the veins operated and developed in the district occur on the south limb along which they were deposited in fissures following the stratification planes during the process of folding of the measures.

The productive veins have been operated over a maximum length of one mile and a half and a width of 1,600 feet and dip south from 70° to 80° . On several of them very rich pay-chutes have been worked, all of which pitch eastward, like the anticlinal fold, excepting possibly the pay-chute worked on the Eureka lead, which may dip westerly for some local cause.

The present developments show that the paying portions of the veins occur along three well-defined lines or zones, closely related to the general structure of the district, which may be called the eastern, middle and western pay-zones.

Eastern
pay-zone
Barachois
mine.

At the Barachois mine, at the eastern end of the district, a well defined zone of auriferous veins occurs between 200 and 300 feet to the south of the anticline, and pay-chutes pitching east have already been profitably worked on the Romkey, Twin and Hamilton leads. The pay-chute on the Romkey was worked 1,000 feet in length and 200 feet in depth. The leads curve gently eastward towards the anticline and extend to the north end of Barachois island.

Several other veins, some of large size, have been uncovered to the north and south of this belt. They should be developed further west, along the pay-zone extending westward, across Rudehill and Barachois brook, towards Eureka mine. The extraordinarily rich float, found along the shore at Doody head, has undoubtedly drifted from this zone, the direction of the drift being S. 9° E.

Eureka mine. At a distance of 2,500 feet west of the Barachois mine on the eastern pay-zone and 500 feet south of the anticline, the Eureka lead has been worked 500 feet in length and 210 feet deep.

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Between the Eureka and the Hattie-Mitchell workings there is a length of 2,250 feet of promising ground along the pay-zone, which being covered with drift, is wholly undeveloped, but should also be prospected. Rich float has been found along this zone on area 11, block I, on the Old Provincial Mining company's property, which should be traced to its source.

A rich pay-chute pitching east was operated for 800 feet in length and 240 feet in depth on the Hattie-Mitchell belt, situated 1,000 feet to the south of the anticline; and, 150 feet farther south, the De Barres, or middle belt, was worked 800 feet in length and 80 feet in depth.

The measures have been much disturbed in this vicinity by a series of faults radiating towards the south and south-east and crossing the Major Norton, Creighton, Hog, Halliday, Hattie-Mitchell, De Barres, Washington, Air-shaft, Plough and Caledonia leads. All these leads have been proved to be auriferous and worked more or less along a zone extending also towards the south. This zone of pay-veins and the faults have probably been caused by stresses developed towards the south by the meeting of the north anticlinal and synclinal folds.

The heaviest fault has been well determined by Mr. Matthew McGrath's development works on the Plough lead belt, showing a horizontal throw of 130 feet to the north and a down-throw of 57 feet, on the east side.

A pay-chute of quartz, 18 feet wide, pitching east 16° , has been extensively worked and developed on the Plough lead belt across three properties for a length of 1,150 feet and a maximum depth of 352 feet. The chute is formed by numerous quartz anglers of fissures dipping south into the Plough lead belt.

These anglers appear to extend to the south-east and north-west across the formation and constitute a zone of special enrichment on the Moore, Caledonia, Plough, Wiscassett, Washington, McKenzie, Gillis and Mundie leads which have been more or less worked. All the pay-chutes on this zone pitch eastward.

A very rich and regular pay-chute pitching east 26° has been worked on the Caledonia lead for 500 feet in length and 175 feet in depth, to a small fault, beyond which it has not yet been found.

The Moore lead has also proved rich and has been worked 400 feet in length, and 190 feet in depth. It is cut at the western end of the works by a left hand fault running north-east. Several very large belts of

quartz of low grade have been developed to the south of the Moore lead, and rich float has been found immediately north of it.

The Wiscasset and Washington belts have been worked, respectively, 375 and 250 feet in length and 65 and 75 feet in depth.

Mines in
operation.

Three companies were operating in the district last summer. The Plough Lead Mining company were successfully working the Plough lead at the depth of 180 feet. The Old Provincial Mining company has completed a shaft 352 feet deep on the Plough lead, and is preparing to develop the pay-chute cut at that depth. L. W. Getchell & Co. were operating the large belts of quartz lying immediately south of the Moore lead, on the Napier Gold Mining company's property. Some development works were also being done on the Barachois, Eureka and Stuart properties.

Quartz-mills.

There are at present six quartz mills erected in the district: the Plough Lead Mining company's mill—15 stamps; the Old Provincial Mining company's mill—10 stamps; the Napier Gold Mining company's mill—10 stamps; the Eureka mine's mill—10 stamps; the Barachois mine's mill—10 stamps; and Dr. Eames' Crusher and roasting furnaces to extract gold and arsenic from arsenical-pyritous ores.

The total production of the Wine Harbour gold-district, from 1862 to 1901 inclusive, was 35,422 ounces of gold, from 55,335 tons of ore crushed, valued at \$673,031, giving an average yield of \$12.16 per ton of 2,000 lbs. In 1901, 29,664 tons crushed yielded 5,592 oz. 10 dwts. of gold.

Harrigan Cove Gold District.

Harrigan
Cove Gold
District.

One week was devoted to a survey of the gold district of Harrigan Cove, situated in the county of Halifax, on the Atlantic coast, at a distance from Halifax of 75 miles by water and 100 miles by the coach road. Most of the surveys have been plotted, on the scale of 400 feet to an inch, and the plan will soon be completed for publication. Meanwhile a preliminary description may be given of the general structure of the folds and veins.

A good section of the rocks is well exposed across the district along the area line dividing lot 215 from 216 on the St. Anthony property. It shows that the series have been plicated into one main anticlinal fold, on the south limb of which a subordinate crumple occurs at a distance of 1,250 feet to the south of the axis.

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The main anticline was located on area 616, block 2, along a small swampy brook running eastward, at a distance of 2,000 feet north of the St. Anthony lead. The fold is broad; the angle of dip increasing gradually on both limbs until it reaches 90° half a mile north of the axis and 40° at a distance of 800 feet to the south of it. North anticline.

A few veins have been uncovered on both limbs, at some distance to the north and south of the axis, but none have yet been proved sufficiently auriferous to warrant developments, although some gold float is reported to have been found in the vicinity.

At a distance of 1,250 feet south of the main anticline the strata curve into a synclinal and, 150 feet further, into an anticlinal fold. The two folds converge towards the east and meet on area 390, beyond which the crumple terminates.

The south anticline runs N. $75\frac{1}{2}^\circ$ W. and shows prominently 600 feet north of the St. Anthony lead, along a bold ridge for 1,600 feet, beyond which it is concealed by a hill of boulder clay running transversely north and south. On the north limb the strata dip 35° , while on the south the angle of dip increases gradually and reaches 60° at a distance of 1,500 feet south of the axis. South anticline.

Two left-hand faults were determined crossing the anticline: one, the St. Anthony fault, occurs on the eastern part of area 319, runs S. 25° W. across the auriferous belts, giving a displacement of 90 feet on the anticline; the other passes on area 278, where the throw is 50 feet south, runs southerly and probably meets the former fault between the St. Anthony and the A. Kent Archibald works. Several important faults undoubtedly occur to the westward, but they have not been made out yet. These faults should be kept in mind in the prosecution of surface developments and determined if possible. Faults.

All the veins discovered in the district, follow the planes of stratification and occur on the south limb of the south anticline. The area under development, and including all the veins operated, extends from the south anticline 1,600 feet southward across the stratification and and 2,800 feet east and west along the veins. Auriferous area.

Several large superimposed saddle-veins have been uncovered along the apex of the fold pitching westward at a very low angle. On the north dip they pinch out immediately north of the axis, but on the south limb they extend to a great depth, as is well proved at the surface by the cropping out of a succession of veins extending for a great distance to the south of the axis, the upper portions of which were denuded away to the present surface level. Large undeveloped veins

Some very rich float has been found south of the anticline and twelve large belts of quartz veins have recently been cut in the 600 feet of the strata between the anticline and the St. Anthony lead, most of which are well mineralized and show gold. None of them have, however, been cut yet in more than one or two places along their course, and they offer a very promising undeveloped field for the prospector.

St. Anthony
mine

The St. Anthony lead has proved so far the best producing vein of the district. A rich pay-chute pitching westerly has been worked 200 feet in depth and 500 feet in length to the St. Anthony fault, beyond which it has not yet been recovered. The throw here is to the south and probably less than the 90 feet of displacement measured on the anticline, and there should be no difficulty in finding the lead on the west side of the fault. The St. Anthony lead has been traced 1,600 feet in length east of the fault.

South of the St. Anthony lead the ground is low, swampy and wholly undeveloped.

A. Kent
Archibald
mine.

A great deal of development work has recently been done on the A. Kent Archibald property, situated to the west of the St. Anthony property, and over twenty-five belts of veins have already been uncovered, 300 feet south of the anticline, across 550 feet of strata. Several of the veins, well mineralized and auriferous, have been mined to limited depths. Pay-streaks or rolls pitching westerly occur in a line or zone running north-west and south-east, along which developments should be directed. One of the leads discovered last summer is especially rich in coarse gold, and the debris found along its outcropping showed very fine crystals of gold, in cubes, several of which were secured for the museum through the kindness of Mr. Monroe Archibald. They are the only crystals of gold discovered in Nova Scotia of which I am aware.

Between 400 and 600 feet farther south two large belts of leads have been mined a little on the McMann property.

Port Dufferin
belt.

Some gold-bearing drift has also been found and a few veins lately prospected as far west as Port Dufferin, where this anticline crosses the Salmon river 1,300 feet above the bridge. A crumple of the strata apparently occurs a short distance below the bridge.

Moosehead
mine.

East of the St. Anthony mine the country is generally covered with drift. At Moosehead, three miles east of Harrigan cove, some development work has been done from time to time on a few veins lying immediately south of the anticline.

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In conclusion, it may be said that the very large field of undeveloped auriferous belts here present should draw the attention of the prospector, and that the A. Kent Archibald, St. Anthony and other adjacent properties, already proved productive, are capable of being operated on a much larger scale. It is believed that the plan which has been made will greatly assist in such developments. Conclusions.

Three mills are erected in the district, viz.:—St. Anthony Gold Mining Co.'s mill, 10 stamps; A. Kent Archibald, *et al*, 5 stamps; M. McMann and others, 5 stamps. Quartz-mills.

The gold returns reported from Harrigan cove to the Provincial department of mines, Halifax, for the year 1901, were 4,167 tons crushed, yielding 2,595 ozs. 6 dwts. 9 grs., or an average of 12 dwt. 11 grs. per ton of 2,000 lbs. The returns just received from the provincial Commissioner of Mines for the year 1902 are :— Gold production.

St. Anthony Gold Mining Co.	1,183 tons	yielded	493 ozs.
A. Kent Archibald, <i>et al</i>	1,095	"	750 ozs.
M. McMann and others.	124	"	34 ozs.
Total	2,402	"	1,277 ozs.

Beaver Dam Gold District.

A hurried survey was made of the structure of the gold district of Beaver Dam, situated on the Killag branch of the West river of Sheet Harbour, 7 miles east of the coach road, in Halifax county. Beaver Dam Gold District.
A full description of the district will, however, have to be deferred until the surveys are plotted.

All the veins discovered follow the planes of stratification along an anticlinal fold. No mining operations of any importance has yet been undertaken. A large belt of low grade ore has been developed by a shaft and cross-cut on the Jos. H. Austen, *et al*, property at the east end of the district. In a report submitted to the owners Mr. L. F. S. Holland gives the following measurements:—Shaft 98 feet deep on a belt 15 feet wide, cross-cut north 62 feet, cross-cut south 39 feet, total width of the auriferous belt 74 feet, half of which is quartz and slate giving an average value by sampling of \$3.50 per ton. This belt has been uncovered 400 feet further west. Jos. H. Austen mine.

Three-quarters of a mile further west some very rich drift was found on the Geo. E. Van Buskirk and other adjoining areas, and a great number of leads, some of which are auriferous, have recently been un- Dimock and Zwicker's prospecting.

crossed by Dimock and Zwicker by surface trenches cut across 785 feet of strata. The country is low, all covered with drift, and hence difficult to prospect.

The developments, though limited, have shown auriferous veins over a large area along the anticlinal fold, some of which are rich in gold and others form large deposits of low grade ore which deserve more attention than they have hitherto received.

A 10-stamp mill has been erected on the Jos. H. Austen property, and a good water-power is available on the Killag river within a short distance of the mine.

Gold Districts Examined.

A hurried examination and partial surveys were also made of recent mining developments in the gold districts of Richardson, Doliver Mountain, Goldenville, and County Harbour Narrows, in Guysborough county: of Ecum Secum, Dufferin, Fifteen-mile Stream, Caribou, Moose River, Mooseland, Tangier and Waverley, in Halifax county: of Renfrew and Mount Uniacke in Hants county, and Gold River and Leipsigate in Lunenburg county.

Deep Gold Mining.

Possibility of deep mining demonstrated by geological work.

The knowledge now gained, by a detailed study of the principal gold districts in the province, proves conclusively that the auriferous veins outcropping at the surface on the north and south limbs of the anticlinal folds are the remnants of the north and south legs of the superimposed 'saddle-veins' which once occurred at a higher level than the present surface, and demonstrates that, below, auriferous saddle-veins will be found recurring along the axis-plane of the fold. Moreover, from the analogy of the Australian gold-bearing 'saddle-reefs,' occurring in a similar manner and profitably operated to a depth of 4,000 feet, it may be inferred that the quartz veins in Nova Scotia will, in depth, be as large and as rich in gold as those outcropping at the surface.

Deep mining proved by actual practice.

It is difficult, however, to induce capitalists to invest money in extensive mining developments unless similar undertakings have already proved successful in actual practice. It is, therefore, very gratifying for me to state that the recommendations of the Geological Survey have already been put into practice at the Bluenose, Dufferin, Richardson, Doliver Mountain and other mines, and, although the developments are as yet limited, the results obtained are so satisfactory and

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conclusive that they are attracting the attention of foreign engineers and capitalists and similar developments are being contemplated at other mines.

Mr. C. K. Leith, of the United States Geological Survey, and professor at the University of Wisconsin, reviewing the work of the Geological Survey of Canada in the gold-fields of Nova Scotia, says*: 'Mr. E. R. Faribault's work will be of immediate practical advantage to mining men, some of whom have already testified to its accuracy and value. It is another instance, lately of frequent occurrence, of geological work done from a purely scientific standpoint having direct economic value. From a scientific standpoint, also, the results are of interest as illustrating a principle of ore disposition. In many districts, and particularly in the Lake Superior district, it has long been known that ore deposits were partial concentrates in pitching troughs by descending waters. Van Hise has lately enunciated the principle that the openings in arches or pitching folds are favourable places for the concentration of ore deposits by *upward moving waters*. The formation of the gold-bearing veins of Nova Scotia seems likely to have occurred in this way.'

Economic value of geological work in Nova Scotia.

Bluenose Mine, Goldenville.—Much credit is due to the late Mr. Simon A. Fraser for having first undertaken, and Messrs. Thos. Cantley and A. G. McNaughton for having executed so successfully at the Bluenose mine a new system of mining development on the Goldenville anticlinal fold, which should be an object lesson for the gold miners of the province, as it will, no doubt, be the inauguration of a new era of extensive and permanent deep mining.

Bluenose mine Goldenville.

A detailed survey was made on October 15 last of the new developments and a transverse section was prepared which is here reproduced on a reduced scale. The section is made through the main shaft on the Springfield belt, and along two cross-cuts driven north, one above the other, at the depths of 280 and 364 feet, and at a distance of 30 feet west of the main shaft. The upper cross-cut is 230 feet and the lower 250 feet long. They show the structure of the Goldenville anticlinal fold with a subordinate small flexure on the north leg, and disclose the recurrence of large auriferous saddle-veins, from the surface to below 364 feet.

Transverse section.

The saddle-veins are remarkably well developed on the apex of the fold where they attain a large size, and the legs continue downwards

Recurrence of workable saddle-veins.

* The Journal of Geology, Jan.-Feb., 1906, vol. VIII, No. 1, page 84.

very regularly on both legs, the veins diminishing but little in size, more especially on the south leg, which goes to prove that they will extend to great depth, as well as parallel with the anticlinal axis.

Most of the veins developed have proved auriferous, and two of them, the McNaughton belt on the south dip and Cantley belt on the north dip, have already been profitably worked.

McNaughton
belt.

The McNaughton belt measures 6 feet 8 inches in width at the upper level and 6 feet at the lower, and is composed of large irregular quartz rolls and stringers pitching westerly 15 degrees to 22 degrees in slate and a few thin layers of whin. It has been opened 300 feet in length on the upper level and 500 feet on the lower, and the greater part of the block of ore between the two levels has been extracted by backstopping. A rise of 65 feet has been made above the upper level, where the belt has widened to eight feet and ten inches and begins to curve towards a saddle higher up. The official returns of the ore extracted from the McNaughton belt for the year 1902 are 11,211 tons, yielding 2,391 ozs. of gold, which is very satisfactory considering the size of the vein.

Springfield
belt.

The Springfield belt was profitably worked to a maximum depth of 400 and a length of 900 feet, and is still found auriferous at the bottom of the main shaft, which is being sunk some 50 feet deeper for a third cross-cut, to develop new saddles and backstope the McNaughton and probably other workable belts already cut. The South Springfield belt was mined 113 feet in depth and 242 feet in length.

Pay-zone on
south dip.

As the McNaughton belt has been profitably mined almost to the apex of the fold, 145 feet above the lower level, we may conclude that the denuded portion of the Springfield belt, about 150 feet, was pay-ore, which added to the depth worked, 400 feet, would give a possible total depth of 550 feet of pay-ore on the south dipping veins. The McNaughton belt may, therefore, be expected to carry pay-ore for 400 feet deeper than the 364 feet level. On the south dip the zone of pay-veins is thus approximately 150 feet in width and lies immediately south of the anticlinal axis, along which it extends to great depth, unless a change should be found in the structure of the fold, of which there is so far no indication. In length the Springfield belt has been profitably worked for 900 feet, and the McNaughton belt will probably be workable for the same length.

- * A continuous zone of pay-veins has been worked to limited depths, all along the south limb of the Goldenville anticlinal fold, for an aggregate length of 4,400 feet, from the Springfield to the Palmerston belt,

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beyond which development work has been prevented by the swampy nature of the ground. The surface developments are sufficient to prove that this zone affords a field of virgin ground, large enough for several mines like that operated by the Bluenose company, and Mr. George W. Stuart is at present sinking a shaft on area 743, seventy-five feet west of the open-cut on the Palmerston belt, in order to develop the zone of pay-veins, which has proved very rich in gold in this vicinity, by a system of cross-cuts and drifts at different levels.

The developments on the north dip at the Bluenose mine, have not yet been sufficient to determine the pay-zone, but on the Cantley belt they show that the workable portions of the veins are restricted to certain parts of the subordinate flexure occurring on the north limb of the main anticline, and further developments will no doubt determine some well-defined zones of pay-chutes pitching, like the flexure, easterly 20 degrees.

Pay-zone on
north dip.

The most regular and continuous pay-chutes worked in Goldenville were operated on the north limb of the anticline. In the plan and report of that district, published in 1897, three zones of pay-chutes are given: the Wellington, Hayden and McRae lines of pay-chutes. In the Summary Report for the same year, page 109, referring to the Hayden line of pay-chutes, I said, 'A swamp lying north-west of the Little Hayden has, no doubt, prevented prospecting further north-west on this undulation, but there is every reason to believe that rich streaks occur there.' It is gratifying to learn that this prediction has been fulfilled and that several rich pay-chutes have since been developed with a great deal of skill by Mr. Wm. McIntosh, the superintendent of the Royal Oak mine, and for the year 1902, 4,310 tons of ore extracted have yielded 2,394 ozs. 16 dwts. of gold.

Royal Oak
mine.

Salmon River Gold District—Dufferin Mine.

A general description of the mining developments on the arch-core of the anticlinal fold at the Dufferin mine, has already been given in the Summary Report for 1899, page 183, and a transverse section showing the structure of the saddle-veins is now ready for publication.

Saddle-veins
developed by
vertical shaft
and cross-cuts.

This section shows that a vertical shaft 420 feet deep with cross-cuts through the anticlinal fold at 134, 200, 315 and 420 feet levels have developed a succession of superimposed saddle-veins, which do not crop at the surface, five of which have been worked between the surface and the 315 feet level.

This mine has been one of the best gold producers in the province: 117,906 tons of ore treated having yielded 41,497 ozs. 5 dwts. 20 grs.

of gold valued at \$788,448, giving an average of 5 dwts. 20 grs. per ton of 2,000 lbs. Through one cause or another, the mine is at present idle, but will undoubtedly be taken in charge again by some skilful mining engineer and operated as successfully as before, which has been the case with several other abandoned mines lately reopened.

Upper Isaacs Harbour Gold District.

Upper Isaacs
Harbour.

A special plan of this district, also called Upper Seal Harbour, was made in 1897 and descriptive notes were published in the Summary Report for that year, in which it was pointed out, at page 106, that 'Large belts of low-grade ore, conforming with and similar to that of the Richardson vein, certainly occur along this fold, but they will only be found on the apex of the fold, along which more prospecting should be done; and this could be accomplished most readily and at least cost by sinking vertical shafts along its axis.' This recommendation has since been successfully put into practice at the Richardson and Doliver Mountain mines.

Richardson
mine saddle-
veins.

Richardson Mine.—At the Richardson mine a vertical shaft was sunk 160 feet in depth, about 900 feet to the eastward of the Richardson vein, intersecting at the depth of about 100 feet the south leg of an overlying saddle-vein giving ten feet of quartz and slate, which was developed by a drift 60 feet eastward and a cross-cut 84 feet long to the north leg which shows six feet of ore. The character of the ore and structure of the saddle-vein are identical with those of the Richardson; but for some cause, the work of sinking has been stopped. The property, however, has been acquired by a strong American company which contemplates important mining developments, by means of a vertical shaft and cross-cuts and with up-to-date equipment; and alterations are already in progress. The large cyanide plant lately erected is to be utilized for a new process of gold extraction, and the 60-stamp mill improved and twenty more stamps added. The production to date from this district shows 73,314 ounces of gold from 226,355 tons of ore treated.

Vertical shaft
intersects
large saddle-
veins.

Doliver Mountain Mine.—At Doliver mountain, on the same anticline and one mile west of the Richardson mine, Mr. G. J. Partington has, during the last two years, developed in a very skilful manner a succession of large saddle-veins similar to the Richardson. The exact position and direction of the anticline and the structure and value of three superimposed saddle-veins outcropping at the surface were first ascertained. These are the Howard, Forge and Partington saddle-veins, measuring respectively 10, 30 and 33 feet vertically on the apex,

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the former pitching eastward 12° and the latter 16°. A vertical shaft, 17 ft. 6 in. x 5 ft. 3 in., was then sunk on the anticline, on area 774, about 400 eastward of the cropping of the Partington belt, to intersect the three saddle-veins as well as others underlying at their apex. After going through 55 feet of quicksand, small veins were intersected at depths of 55, 92 and 102 feet, which, although not apparently of workable size, proved the shaft to be exactly on the apex of the fold.

At the depth of 130 feet the Partington belt was intersected. It is being developed on the north and south legs and has yielded about 6,000 tons of ore, highly mineralized, composed of rolls, bunches and stringers of quartz running through a belt of slate and much resembling that of the Richardson mine. Below the Partington saddle-vein the shaft cut through a very hard bed of quartzose-sandstone or whin, 29 feet thick, then at the depth of 192 feet another saddle, was intersected 22 feet thick, well mineralized and composed of two distinct corrugated lodes and a network of irregular feeders of quartz running through the slate belt. The shaft is now 190 feet deep, but the company will wisely continue the sinking without interruption until the depth of 1,000 feet has been reached. It will thus intersect successively the Forge and Howard belts, already uncovered at the surface, and, no doubt, other new underlying saddle-veins, on the apex of the fold, where they are of greater size and value.

These operations are well worth recording, as the first instance in Nova Scotia where a series of saddle-veins has been systematically developed with due regard to its geological structure and a proper knowledge of its possibilities for extensive and permanent mining. The company is erecting a large, modern plant. A fine water-power is being utilized at the head of tide on Isaacs Harbour river, capable of generating 750 horse power. The power is transmitted by electricity to the mine, where an electrical hoist and fifteen-drill air compressor have been installed, and an eighty-stamp mill in which 40 stamps are to be used at once.

Large water-power plant and mill.

This is certainly one of the best equipped mines to operate large bodies of low-grade ore at a low cost, and it only requires a good plant for the extraction of gold from the sulphides to make it the model gold mine of the province. What has been accomplished at this mine can also be done at several points along the Upper Isaacs Harbour anticlinal fold and in many other districts where the conditions are favourable, particularly Isaacs Harbour, Goldenville, Salmon River, Mooseland, Tangier, Oldham, Waverley, Fifteen-mile Stream, Renfrew, etc.

Model plant.

Methods of Deep Gold Mining.

Deep mining
at Bendigo.

At Bendigo, Australia, the systems of saddle-reefs are being developed in depth by means of vertical shafts sunk on the anticlines, and a succession of cross-cuts and drifts at about every hundred feet. It is, therefore, very desirable that the vast experience gained in that field should be taken advantage of by those contemplating the development of our Nova Scotia systems of saddle-veins. Much practical information may be obtained from the official reports of the Victoria department of mines at Melbourne, and other literature published on the subject in the transactions of the Australian mining and scientific societies.

Location of
vertical shafts.

The success of deep mining depends above all on the proper location of the vertical shafts, and this can only be done after a careful study of the structure and conditions peculiar to each district. Some districts are especially suitable for such developments, while others are not, although they may have proved good gold producers over a large area. Second in importance to the location of the shafts, is the direction and length of the cross-cuts and drifts to intersect the pay-veins.

Vertical and
inclined folds.

In the case of anticlinal folds, where axis-plane is vertical, like that of Upper Isaacs Harbour, Mooseland, Tangier, Dufferin and Oldham, a vertical shaft would run parallel with it; but if the axis-plane dips at an angle from the vertical, as at Goldenville, Fifteen-mile Stream, Waverley and Renfrew, the vertical shaft would necessarily approach or recede from the axis as it is sunk to greater depth, according to its position with reference to the axis. In the first case, very little cross-cutting would be necessary, if the shaft is properly located as it would keep in the pay-zone all the way down; but in the latter case, the deeper the shaft the more cross-cutting will have to be done. The dip of the anticlinal axis has thus to be taken into consideration in locating a vertical shaft, so that unnecessary cross-cutting may be avoided.

Testing of
the veins.

The veins intersected should be carefully sampled and separate mill-tests made of the most promising, to determine the workable portions and pay-chutes. It is very desirable that the structure of the strata and veins intersected should be recorded on a large scale plan, before it is concealed by the timbering of the shaft. A complete set of underground plans and sections should also be kept of cross-cuts, drifts, winzes, rises, etc., showing the value, size and structure of the veins opened up. Such plans would show the distribution of the ore-bodies in the area developed and assist in defining the direction and extent of the pay-zone and in laying out the development works.

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Advantage should be taken of the fine water-powers which are lying idle in close proximity to most of our mines, now that gold mining is being established in the province on a more permanent footing, as they would greatly lessen the cost of operation. The transmission of power by compressed air for short distances and by electricity for longer distances has proved to be practicable and is extensively and successfully used outside of the province.

CHEMISTRY AND MINERALOGY.

Dr. G. C. Hoffmann.

Reporting on the work done in these branches of the Survey's operations, Dr. Hoffmann says:—‘The work carried out in the chemical laboratory during the past year’ has been, in pursuance of the practice of former years, almost exclusively confined to the examination of such minerals, ores, etc., as were considered likely to prove of more or less economic value and importance. Briefly summarized this work included :

‘1. Analyses of fuels, namely—of peat, from the thirty-fourth lot of the sixth concession of the township of Lancaster, Glengarry county, province of Ontario ; and from a point some sixty-seven miles up from the mouth of the Kwataboahagan, a tributary of the Moose, in the same province. Of lignite, from Lepine creek, a stream flowing into Rock creek—which is a tributary of the Klondike, Yukon territory. Of lignitic coal, from near the head of Kettle river, Yale district, in the province of British Columbia. Of coal, said to occur near White Horse, Yukon territory ; and from near the head of Kettle river, Yale district, in the province of British Columbia. Of semi-anthracite, from near Blairmore, district of Alberta, and of anthracite, stated to have come from near White Horse, Yukon territory.

‘2. Analyses, more or less partial, of iron ores from, among other localities,—The farm of John Hatley, Cleveland, Annapolis county, and from Georges river, Cape Breton county, in the Province of Nova Scotia. The first lot of the eighth range of the township of Wolfstown, county of Wolfe ; and from Chicoutimi county, in the province of Quebec. The fifteenth lot of the fifth concession of the township of Oso, Frontenac county ; the thirty-first lot of the twelfth concession of Grattan, Renfrew county ; from near Flying Post, Mattagami river, district of Algoma ; and from south of Waboose lake, same district, in the province of Ontario. From a deposit on Sutton Mill lake, west side of

James Bay, near Cape Henrietta Maria, in the district of Keewatin; and from Port Kells, on the south side of the Fraser, district of New Westminster, in the province of British Columbia.

Nickel ores.

'3. Analyses, in regard to nickel content, of pyrrhotite from the following localities:—In the province of Ontario, from the seventeenth lot of the second concession of the township of Westmeath, in Renfrew county; the tenth lot of the fourth concession of the township of Olden, in Frontenac county; from a cutting on the Whitney and Opeongo Railway, about seven miles and a quarter from its junction with the Canada Atlantic Railway, township of Sproule, in the Nipissing district; from the eighth lot of the fourth concession of the township of Dowling, and from the fourth lot of the fourth concession of the township of Graham, both in the district of Algoma. In the province of British Columbia, from a mountain on the west side of Ice river, about six miles from the forks of Ice and Beaverfoot rivers, in the East Kootenay district; the north bank of the Thompson, about five miles above Lytton, as likewise from Shuswap lake, in Yale district. Analyses were also made of specimens of this mineral from the fourteenth lot of the fifth range of the township of Masham, Ottawa county, in the province of Quebec; and from about a quarter of a mile north of Boularderie Centre, Victoria county, in the province of Nova Scotia.

Gold and silver.

'4. Assays of numerous samples of material for gold and silver from localities in the provinces of Quebec and Ontario; the district of Keewatin; the Yukon territory; the districts of East and West Kootenay, Yale, Lillooet, Cassiar, New Westminster, and from Vancouver island, in the province of British Columbia.

Limestone and dolomite.

'5. Analyses, complete or partial, of limestones and dolomites (in continuation of the series of analyses of such stones already carried out, in connection with an inquiry into their individual merits for structural purposes, for the manufacture of lime, or of hydraulic cement, or for metallurgical purposes, etc.), including, that of a dolomite from Brookville, St. John county, province of New Brunswick; of limestone from the Archambault quarry, on the twenty-sixth lot of the seventh range of the township of Weedon, Wolfe county, province of Quebec; of a limestone from a quarry on the thirty-fourth lot of concession A of Ottawa Front, township of Nepean, Carleton county; and of a dolomite from Walkerton, Bruce county, in the province of Ontario.

Natural waters.

'6. Analyses of natural waters—with the object of ascertaining their suitability for economic or technical purposes, or possible value

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from a medicinal point of view—from the undermentioned localities :—
 From a spring on lot 1 of the 1st concession of the township of Scarborough, York county, and from a well in the village of St. Joseph, Huron county, in the province of Ontario; from a spring about four miles back from the west bank of the Fraser, nearly opposite the mouth of Big Bar creek, Lillooet district, and from a spring at Chilcotin, about twenty-three miles from Chimney creek ferry, Cariboo district, in the province of British Columbia.

‘7. Analyses of several minerals of economic value, some of which had not previously been recognized as occurring in Canada, and of others, from localities where they were not previously known to occur, as for instance: 1. Of chrompicotite, a variety of chromite, or chromic iron, which has been met with in considerable quantity on Scottie creek, some seven miles east of Mundorff, in the district of Lillooet, province of British Columbia. This mineral had hitherto been found in but one locality, namely, at Dun Mountain, in New Zealand. The find may prove to be of considerable commercial value, as a source of chromium, which is used, among other purposes, in the manufacture of bichromate of potash, a preparation employed for calico-printing and in certain forms of electric batteries and for other purposes; as likewise for the preparation of the pigments chrome-yellow, orange and green, and also to some extent in the production of what is known as chrome-steel. 2. Of native antimony, which has been found at the Dufferin mine, on the 18th lot of the 1st concession of the township of Madoc, Hastings county, in the province of Ontario. 3. Of a series of specimens of what, as a result of this examination, has now been shown to be magnesite with variable, often comparatively small, quantities of intermixed dolomite, from more or less extensive exposures, and drift boulders, of the same, occurring in the township of Grenville, Argenteuil county, in the province of Quebec. The economic importance of this occurrence, may be inferred from the fact that magnesite is used in the preparation of magnesian salts—such as Epsom salts, magnesia, etc., also in the manufacture of paint, paper, and fire-brick, for which last named purpose it is especially well adapted, particularly where a highly refractive material is needed, as in the so-called basic process of iron-smelting. 4. Of an altered felsite from within half a mile of the stage stables at Hay cove, Red islands, Richmond county, in the province of Nova Scotia, where, from the information received, it is inferred that it occurs in considerable quantity. From experiments made with this material in the laboratory it is considered that it would make a fairly refractory fire-brick, in which regard it resembles the altered felsite from Watson

Number 15
 minerals of
 economic
 value.

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brook, Cape Breton county, in the same province, the results of the examination of which, by the writer, are given in the Report of Progress of this Survey for 1875-76, p. 423. 5. An analysis of the somewhat rare mineral faujasite, a species not previously recognized as occurring in Canada, which was found, as described in my last report (Annual Report of this Survey, vol. 12, p. 17B, 1899), associated with the datolite met with in the workings of the Daisy mica mine, on the 9th lot of the 1st range of the township of Derry, Ottawa county, in the province of Quebec. 6. An analysis of a very beautiful amphibole from the township of Grenville, Argenteuil county, province of Quebec, which would appear to be adapted for an ornamental stone or for use in jewellery. 7. An analysis of a sample of underclay from a seam of lignite on Rock creek, about nine miles up from its entry into the Klondike, Yukon territory. This clay, the chemical composition and physical characters of which proved to be somewhat exceptional, was found to possess the property of decolorizing mineral oil, in which regard it resembles a fuller's earth. Examinations have also been made of many minerals from localities where they had not hitherto been met with, namely, of lampadite, or cupreous manganese, from the King Solomon mine, Copper camp, at the head of Copper creek, Yale district, in the province of British Columbia: of native copper, also from the King Solomon mine: of tremolite, from the Morrison mine, Deadwood camp, some three or four miles north-west of Greenwood city, Yale district, province of British Columbia: of rutile, from a quartz vein on Thistle creek, a tributary of the Yukon, Yukon territory: of bismuthinite, from the Blue Bell claim, Summit camp, near the head of Fisherman creek, Yale district, province of British Columbia: of melaconite, malachite, azurite, and cuprite, all from the King Solomon mine, Copper camp, at the head of Copper creek, Yale district, province of British Columbia: and of an asbestiform actinolite from a point on the Klondike about a mile and a half from its entry into the Yukon, Yukon territory.

Examinations
of clays.

8. Miscellaneous examinations, embracing: The examination of samples of clay in regard to their suitability for the manufacture of bricks, ordinary building bricks and fire-bricks, sewer-pipe, terra-cotta, stoneware, etc., from Marble mountain, Inverness county, province of Nova Scotia; Summer hill, parish of Galetown Queens' county, and from the left bank of the Miramichi, about eighteen miles from its entrance into Miramichi bay, Northumberland county, in the province of New Brunswick; from the mouth of Savage river, a tributary of the Patapedia, Bonaventure county, from the four hundred and fifty-ninth lot

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of the first range north-east, on the Chaudière, seigniory of St. Joseph, Beauce county, and from the fourteenth lot of the first range of the township of Wakefield, Ottawa county, in the province of Quebec; from the thirty-fourth lot of the sixth concession of the township of Lancaster, Glengarry county, and from the ninth lot of the eleventh concession of the township of Greenock, Bruce county, in the province of Ontario; from one mile west of the junction of the South fork and Little South fork of the Old Man river, district of Alberta, and from the Red Deer river, in the same district, as likewise from the vicinity of Moosomin, district of Assiniboia, in the North-west Territory; from Arrow lake, West Kootenay district, and from Texada island, Strait of Georgia, in the province of British Columbia.

The examination of a series of samples of the sand forming the Traverse Spit, at the foot of the Island of Orleans, and of that forming the Ste. Croix and Champlain shoals, between Three Rivers and Quebec, in the lower St. Lawrence, province of Quebec; of a siliceous sand from about two miles from the town of Shelbourne, Shelbourne county, province of Nova Scotia; of a sand from the bottom of a small lake on the eleventh lot of the tenth concession of the township of Greenock, Bruce county, in the province of Ontario; of an auriferous black sand from Adams hill, near Bonanza creek, and of a black sand from White Horse, Lewes river, Yukon territory. The examination of a marl from the fourteenth lot of the first range of the township of Wakefield, Ottawa county, and of that of another from the eleventh lot of the tenth range of the township of Bristol, Pontiac county, in the province of Quebec, as likewise of that of one from Loughborough lake, in Frontenac county, and of another from Odessa lake, Lennox county, in the province of Ontario. The examination of some silts from the township of Greenock, Bruce county, province of Ontario. The examination of an ore of manganese from Soldier cove, Bras d'Or lake, Richmond county, province of Nova Scotia; of a concretionary nodule from the vicinity of Sorel, south shore of the St. Lawrence, province of Quebec; of calcareous shales from Arnold, province of Manitoba; of a carbonaceous shale from Harris brook, Victoria county, province of Nova Scotia; of a bituminous shale from Chambord, township of Metabetchouan, Chicoutimi county, province of Quebec; of a sample of copper ore from Field, East Kootenay district, province of British Columbia; of a disseminated graphite from the ninth lot of the tenth concession of the township of Ross, Renfrew county, province of Ontario, and of another from Rivers inlet, in the province of British Columbia, as likewise of a prepared graphite from

the works of the Dominion of Canada Plumbago Company, township of Buckingham, Ottawa county, province of Quebec; of an altered bitumen from the Falls on the Middle Fork of the Old Man river, district of Alberta, North-west Territory; of a sample of pyrite from the fourteenth lot of the fifth range of the township of Masham, Ottawa county, in the province of Quebec.

Various
examinations.

Examinations were also made of a great variety of other material from various parts of the Dominion, much of which, including those above referred to, called for, at least, a partial analysis.

'The total number of mineral specimens received for identification, analysis, or the obtaining of information in regard to their possible economic value during the past year, amounted to seven hundred and ninety-one (791). Many of these were brought by visitors, and the information sought in regard to them was in most cases communicated to them at the time of their calling. In other instances, however, such as those where a partial or complete analysis was considered desirable, as also in the case of specimens which had been sent from a distance, the results were communicated by letter. The number of letters personally written, in this connection,—chiefly of the nature of reports, and embodying the results of the examination, analysis, or assay, as the case might be, of mineral specimens—amounted to three hundred and twenty-one; and of those received, to one hundred and fifty-two.

Assistants in
laboratory.

'Messrs. R. A. A. Johnston and F. G. Wait, assistants in the laboratory, have, as a result of the interest taken by them in their work, and their close and unremitting application to it, proved most efficient aids. Briefly stated, Mr. Johnston has carried out a large number of gold and silver assays, made many important mineral analyses, and, further, conducted a great variety of miscellaneous examinations; whilst Mr. Wait has made numerous analyses of natural waters, some mineral analyses, many partial analyses, and, in addition, also carried out very many miscellaneous examinations; all of which work will be given in detail in my ensuing annual report.

Assistant in
mineral
section.

'In the work connected with the mineralogical section of the museum, I have, as in previous years, had the hearty and able assistance of Mr. R. L. Broadbent. He has, in addition to the usual routine work of the museum—such as the labelling and cataloguing of all newly received specimens, and the maintenance of the collection generally in an orderly condition—also spent some time in the field for the purpose of collecting specimens for the museum, as well as others for

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Mr. Willimott's use in making up collections for distribution to Canadian educational institutions. With this object in view, he visited several localities in the township of Hull, Ottawa county, of Grenville, Argenteuil county, and those of Litchfield and Calumet, Pontiac county, in the province of Quebec; and, further, the township of Ross, Renfrew county, and that of Lanark, Lanark county, in the province of Ontario. The minerals collected by him comprised :—

Minerals collected.

	Specimens.	Weight.
Barite.....	.....	200 pounds.
Fluorite (green).	13	
Porphyry.....	.....	215 "
Scapolite.....	120	
Wollastonite.....	18	
Hornblende.....	.....	100 "
Magnesite.....	.....	150 "
Dolomite.....	200	
Zinc blende. ....	.....	300 "
Limestone (marble).....	.....	250 "
Galena.....	350	
Iron pyrites.....	.....	300 "
Magnetite.....	.....	350 "

He has also devoted some time, to the preparation of a list of the additions to the mineralogical section of the museum during the last nine years. This, when completed, is intended to form an appendix to the "Catalogue of Section One of the Museum" (which embraces the systematic collection of minerals and the collection of economic minerals, etc.) published in 1893, thereby bringing it up to date.

The additions to the mineralogical and lithological section of the museum, during the past year, embraced :—

Minerals added to museum.

(A.) *Collected by members of the staff engaged in field-work in connection with the Survey :—*

Ami, Dr. H. M.—

a. Mica (muscovite), garnet (almandite), felspar, graphic granite, garnetiferous gneiss, and hornblende, from Lac du Pied des Monts, Charlevoix county, Q.

b. Barite from lots 16 and 17, con. II of Kingston, Frontenac county, O.

Bell, Dr. R. :—

Zinc blende (sphalerite), from lots 5 and 6, con. III of Olden, Frontenac county, O.

Brock, R. W. :—

- a. Cuprite, native copper, malachite, melaconite and lampadite, from the King Solomon mine, Copper Camp, Boundary creek district, B.C.
- b. Bismuthinite, from Blue-bell claim, Summit camp, Boundary creek district, B.C.
- c. Tremolite, from Morrison mine, Deadwood camp, Boundary creek district, B.C.
- d. Calcite crystals from Knob Hill mine, Phoenix (Greenwood camp), Boundary creek district, B.C.

Dowling, D. B. :—

- a. Magnetite from Sutton lake, west side of James bay, district of Keewatin.
- b. Calcite from Equan river, district of Keewatin.

Leach, W. W. :—

- Coal from the Coal creek, Michel and Morrissey mines, Crows Nest Coal Field, East Kootenay district, B.C.

McKinnon, A. T. :—

- a. Gypsum from Clarks Head, Parrsboro', Cumberland county, N.S.
- b. Amygda'oid from Two Islands, Cumberland county, N.S.

Wilson, A. W. G. :—

- a. Hematite from south of Waboose lake, south-west of Lake Nipigon, district of Thunder bay, O.
- b. Dolomite from north-east side of Narrows leading to Chiefs bay, Lake Nipigon, O.

(B.) Received as presentations—

Allan, W. A., Ottawa :—

- Fluorite crystals from lot 1, range IX of Derry, Ottawa county, Q.

Ami, Dr. H. M., (Survey) :—

- Fragment of the 'Welland' meteorite, Welland, O.

Brumell, H. P. H., Buckingham, Q. :—

- Contorted band of quartz in limestone, from lot 28, range VI of Calumet island, Pontiac county, Q.

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Chute, J. A., Dawson, Yukon Territory, per J. B. Tyrrell :—

Native gold (crystal) from claim No. 16, Gold Run creek, Dominion creek, Yukon Territory.

Davis, M. P., Ottawa, O., per Dr. H. M. Ami, (Survey) :—

Granite from quarry at Rivière à Pierre, Portneuf county, Q.

Diver, D. :—

Marl from lots 3 and 4, con XI of Egremont, Grey county, O.

Haycock, E. B., Ottawa, per Dr. A. E. Barlow, (Survey) :—

Corundum from lot 14, con. IX of Methuen, Peterborough county, O.

Henderson, C., Madoc, O., per A. Blue, Ottawa :—

Talc from lot 14, con. XIV of Huntingdon, Hastings county, O.

Hungerford-Pollen, C., Fort Steele, B.C., per W. W. Leach, (Survey) :—

Hematite (crystallized) from the Stella mine, near Fort Steele, East Kootenay, B.C.

Low, A. P., Ottawa, O. :—

Dolomite from Hopewell sound, East coast of Hudson bay, Ungava district, N.E.T.

McPhee, Donald, Scotch Road, P. O., Argenteuil Co., Q. :—

Hornblende from lot 15, range IX of Grenville, Argenteuil county, Q. :—

Matheson, P., per Dr. H. M. Ami, (Survey) :—

a. Chalcopyrite, pyrrhotite and galena from Calumet island, Pontiac county, Q.

b. Pyrrhotite from near Renfrew, Renfrew county, O.

c. Quartz with iron pyrites, in chloritic schist, from lot 7, con. VIII of Ross, Renfrew county, O.

Messrs Moberly and Cameron, Collingwood, O. :—

Marl from lots 25 and 26, con. VII and VIII of Flos, Simcoe county, O.

Mitchell, W. D., New Denver, B.C. :—

Silver ores from mines and claims in the Slocan Mining area, West Kootenay, B.C.

- a. Sphalerite with chalcopyrite and galena from the 'Fairy Queen,' southern slope of Ruby mountains.
- b. Galena (so called ribbed ore) from the 'Convention Fraction,' Silver mountain, $3\frac{1}{2}$ m. N. E. of New Denver.
- c. An association of galena and iron pyrites, in quartz, from the 'Snifi' group, Silver mountain.
- d. An association of galena and iron pyrites, in quartz, from the 'Mountain Chief,' Silver mountain.
- e. Galena (so called ribbed ore) from the 'Bosun & Fidelity,' Silver mountain.
- f. A vesicular quartz carrying a little galena, from the 'Empress,' twelve miles east of Silverton.
- g. Quartz carrying small quantities of galena, tetrahedrite, and pyrite, from the 'Mollie Hughes,' foot of Goat mountain.
- h. Quartz carrying small quantities of tetrahedrite, from the 'Capella' group, Goat mountain, one-quarter mile east of New Denver.
- i. An association of quartz and calcite carrying a little tetrahedrite and pyrite, from the 'Ceylon,' Goat mountain, north of the Capella group.
- j. A honeycombed quartz, stained and coated with ferric hydrate, from the 'Queen City' group, one mile east of New Denver.
- k. A massive, fine to coarse, crystalline galena, from the 'Eclipse,' Silver mountain.
- l. Quartz carrying small quantities of galena, from the north-west slope of the Ruby mountains.
- m. Molybdenite from Wilson creek, Slocan lake, West Kootenay district, B.C.

Nadeau, J. A., Iberville, Q., per Dr. H. M. Ami, (Survey):—

Granite from the Mount Johnson quarries, Iberville county, Q.

Osman, C. J., M.P.P., Hillsborough, N.B., per Dr. R. W. Ells, (Survey):—

Gypsum showing wavy markings, from Hillsborough, Albert county, N.B.

Tyrrell, J. B., Dawson, Y. T.:—

Cassiterite (wood tin) from claim 39 above Discovery, Hunker creek, Yukon territory.

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Wood, Hon. Josiah, Sackville, N.B.:—

- a. Copper ore from the Intercolonial Copper Company's mine, Dorchester, Westmoreland county, N.B.
- b. Copper ore (ground).
- c. " (roasted).
- d. Copper solution.
- e. Electrolytic copper.

Rock
specimens
acquired.

In addition to the foregoing, there have also been added to this section of the museum :—

258 specimens of rocks with microscopic sections, from the east side of Lake Winnipeg, collected by J. B. Tyrrell.

50 specimens of rocks with microscopic sections, from the Sudbury mining district, Ont., collected by Dr. R. Bell.

Educational
collections.

Mr. C. W. Willimott was engaged during the early part of the year in making up collections of minerals and rocks for various educational institutions. Later on, in the month of July, he visited the township of Wakefield, Ottawa county, P.Q., on which occasion he collected the following material :—

Garnet (almandite).....	200 specimens.
Scapolite.....	200 "
Diorite.....	200 "
Phlogopite.....	300 crystals.
Apatite crystals in calcite	150 specimens.
Pyroxene crystals.....	750 "
Serpentine.....	100 lbs.
Calcite.....	100 "

He received from

Mr. Allan McKinnon :—

Agate, about.	300 lbs.
Fibrous gypsum, about.....	200 "

Mr. D. Farry, Ottawa :—

Shell marl.....	25 lbs.
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Mr. Robertson, Albert mines, N.B.:—

Albertite	1 barrel.
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Mr. Parks, Eganville, Ont.:—

Aventurine (feldspar).....	40 lbs.
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Collections
sent.

The following is a list of the educational institutions to which named collections of minerals have been sent during the year :—

	Specimens.
St. Denis Academy, Montreal.....	75
Public school, W. Pubnico, Yarmouth county, N.S....	75
Jacques Cartier Normal School, Montreal, Que.....	100
Les Sœurs de la Congregation de Notre Dame, Sherbrooke, Que.....	75
Public school, Warkworth, Northumberland co., N.B....	100
Sacred Heart Academy, Montreal, Que.....	75
St. Urbain Academy, Montreal, Que.....	75
Public school, Dundela, Ont.....	100
Cookshire Academy, Cookshire, Que.....	100
Sisters of Charity, St. Bernards School, Moncton, N.B....	100
Public school, Boistown, N.B.....	100
" Brighton, Digby co., N.S.....	75
Convent of Sacred Heart, Sault Ste. Reçollet, Que.....	75
Freeport school, Freeport, Digby co., N.S.....	125
Public school, Eganville, Ont.....	100
" Comox, B.C.....	75
Dalhousie College, Halifax, N.S.....	125
Public school, Ulverton, Que.....	100
Academy of St. Joseph, Montreal, Que.....	100
St. Paul's College, Varennes, Que.....	100
Collegiate Institute, Ridgetown, Ont.....	125
School, District No. 2, Pt. Wolfe, Albert co., N.B.....	100
Alexandra school, St. John, N.B.....	100
Louisburg school, Louis-burg, C.B., N.S.....	100
Agnes and Megantic Model School, Lake Megantic, Que.	100
Public school, Armstrong, B.C.....	100
High school, Vernon, B.C.....	125
Public school, Sandwich, B.C.....	100
School, Chester, Lunenburg co., N.S.....	125
High school, Mabou, C.B., N.S.....	75
Village school, Melbourne, Que.....	75
High school, Toronto Junction, Ont.....	125
Cambridge St. school, Ottawa, Ont.....	100
Grammar school, Sussex, N.B.....	100
Public school, Grand Forks, B.C.....	100
College St. school, Halifax, N.S.....	100
High school, Somerset, Kings co., N.B.....	125
Industrial Advocate, Halifax, N.S.....	75
Derby Superior school, Millerton, N.B.....	100
Public school, Richmond, Ont.....	100
Museum, Gerrard Road, Rotherham, Eng.....	125
College St. Louis, St. François de Beauce, Que.....	100
St. Alban's school, Brockville, Ont.....	100
Congregation de Notre Dame, Port Hood, C.B., N.S....	75
Loyola College, Montreal, Que.....	125
Collegiate Institute, Chatham, Ont.....	125
School, Parkers Ridge, N.B.....	75
Sacred Heart, Arthabaskaville, Que.....	100
Bellevue Convent, Notre Dame de Bellevue, Que.....	75
London School Board, London, Eng.....	75
Public school 170, New York, U.S.....	75
Convent Jesu Marie, St. François de Beauce, Que.....	75
Normal school, Vancouver, B.C.....	125
Public Library, Bruce Mines, Ont.....	125
High school, Bridgetown, N.S.....	125
Collegiate Institute, Brockville, Ont.....	125
" Jarvis St., Toronto, Ont.....	125
Government Agricultural school, Compton, Que.....	125
Coaticook Academy, Coaticook, Que.....	125
Public school, Dresden, Ont.....	75
High school, Athens, Ont.....	125
Public school, Bideford, P.E.I.....	75
Guillet's school, Ottawa, Ont.....	75

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The undermentioned have also been supplied with certain specimens of Canadian minerals, viz.:—

R. M. Thorburn, St. John's, Newfoundland.	4
H. Parkhurst, Rockport, Ont.	4
T. J. McFarlane, New Glasgow, N.S. (in exchange). . . .	34
W. E. Cunningham Lamott, Pennsylvania, U.S.	1
H. Piers, Provincial Museum, Halifax, N.S.	2
Ed. Locke, Shrub Hill, Worcester, England.	3

REPORT OF THE MINES SECTION FOR 1902.

Mr. E. D. Ingall.

Of the work of the Mines Section, Mr. E. D. Ingall reports as follows:—

The functions of the Section in relation to the mineral resources and Staff. industries of Canada have been performed during the past year as far as the means at disposal permitted. The staff of the Section numbers three, namely: the officer in charge, upon whom, in addition to the general direction of the Section, most of the technological work devolves; Mr. J. McLeish, who, besides what help he renders in the general work, has special charge of the statistics, and Mrs. W. Sparks whose duties are numerous and general. During part of the winter months Mr. T. Denis, formerly attached to the staff but now entrusted with field geological work, has helped in the technological work. For four months during the summer and part of the winter, Mr. Ingall was engaged in field geological work in the district of Algoma.

As comparison has been frequently and publicly made of the results attained by us with those of the equivalent branch of the Geological Survey of the United States, it may be well to draw attention to certain facts bearing upon this point, without which such a comparison is misleading.

Comparison
with United
States.

The objects of both branches are practically the same, viz: to study and report upon the economic mineral resources of the country, and upon the mineral industries resulting from their exploitation. The results attained take shape chiefly in the form of the annual reports, which should contain, not merely the statistics illustrative of the mineral production but technical descriptions of the mining and allied industries; concise descriptions of the mineral deposits, etc.

The statistics have been issued regularly by this Section since 1886, taking the form of a preliminary advance statement, issued soon after the close of the year dealt with, followed later by the full annual

report giving revised and more complete figures accompanied by much explanatory matter. From time to time special technological articles have been included covering various industries, and a commencement is now being made to carry out the plan suggested some years ago, of issuing these in pamphlet form under the name of bulletins.

Cost of each.

With the extensive field of work offered by the Dominion with its scattered and mostly unorganized mineral industries, it has been found impossible to do more than make a beginning along these lines, and with the present rapid growth of our mineral industries a much more vigorous policy is needed to meet even the most pressing needs of those interested directly or indirectly in exploiting our mineral resources. As giving some idea of the cost of such work it may be mentioned that the Division of Mining and Mineral Resources of the United States Geological Survey has at its disposal an annual grant of \$50,000, whereas we receive only about one-tenth of that amount. The staff engaged on their work numbers some thirteen besides outsiders who write up special industries, where we number from two to four only. It is true their mineral industries produce fifteen times as much as those of Canada, but owing to the mineral deposits of our own country being scattered over so extensive a territory, and to the industries being as a rule unorganized and often ephemeral, the work of keeping in touch with discovery and development is proportionately very much greater.

In view therefore of these facts and of the present needs of the public interested in our mineral resources and industries, it would seem that the time is quite ripe for the reinforcement of the Mines Section, so that it may more vigorously and completely carry out the policy inaugurated in the past, but largely held in abeyance so far by want of means.

Advance statements.

An attempt has been made in the following pages to give a resumé of the mineral industry of Canada. The advance statement herewith reproduced, was issued on the fourth of the month, and to it is added any information as to the different industries which was not available thus early in the year (13th March). It is hoped that an extension of the system may be possible in the future, rendering available more complete and reliable data even thus early. At present however much of the matter given in this preliminary statement must be taken as subject to revision later in the year.

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SUMMARY OF THE MINERAL PRODUCTION OF CANADA
IN 1902.

(Subject to Revision.)

PRODUCT.	Quantity. (a)	Value. (a)
METALLIC.		\$
Copper (b)	Lbs. 39,168,202	4,553,695
Gold, Yukon.....	8 14,500,000	
" all other.....	6,241,245	
		20,741,245
Iron ore (exports).....	Tons. 428,901	1,065,019
*Pig iron from Canadian ore.....	" 71,665	1,043,011
Lead (c).....	Lbs. 23,000,000	935,870
Nickel (d).....	" 10,633,410	5,025,903
Silver (e).....	Oz. 4,373,000	2,280,957
Zinc	Lbs. 166,700	8,063
Total metallic.....		35,653,708
NON-METALLIC.		
Actinolite.....	Tons. 550	4,400
Arsenic	" 800	48,000
Asbestos.....	" 31,779	1,191,338
Asbestic	" 8,662	12,114
Chromite	" 900	12,400
Coal	" 7,639,255	15,538,611
Coke (f)	" 506,466	1,538,930
Corundum.....	" 768	84,468
Felspar.....	" 7,576	11,375
Fire clay.....	" 2,741	4,283
Graphite.....	" 1,005	28,300
Grindstones.....	" 6,159	48,400
Gypsum.....	" 332,045	356,317
Limestone for flux	" 293,198	218,869
Manganese ore	" 84	2,774
Mica	"	400,000
Mineral pigments—		
Baryta.....	" 1,066	3,957
Ochres.....	" 4,955	30,495
Mineral water.....		100,000
Moulding sand.....	Tons. 13,352	27,651
Natural gas (g).....		195,992
Peat.....	Tons. 475	1,663
Petroleum (h).....	Brls. 521,485	934,740
Phosphate.....	Tons. 856	4,953
Pyrites	" 35,616	134,939
Salt	" 63,056	288,581
Talc	" 680	1,804
Tripolite	" 900	15,800

* The total production of pig iron in Canada in 1902, from Canadian and foreign ores amounted to 357,903 tons, valued at \$4,243,545, of which it is estimated 71,665 tons, valued at \$1,043,011, should be attributed to Canadian ore and 286,238 tons, valued at \$3,200,534, to the ore imported.

(a.) Quantity or value of product marketed. The ton used is that of 2,000 lbs.

(b.) Copper contents of ore, matte, &c., at 11·626 cents per lb.

(c.) Lead contents of ores, &c., at 4·069 cents per lb.

(d.) Nickel contents of ore, matte, &c., at 47 cents per lb.

(e.) Silver contents of ore at 52·16 cents per oz.

(f.) Oven coke, all the production of Nova Scotia and British Columbia.

(g.) Gross return from sale of gas.

(h.) Includes crude oil sold to refiners and oil sold for fuel and other purposes.

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SUMMARY of Mineral Production of Canada in 1902—*Concluded*.

PRODUCT.	Quantity. (a)	Value. (a)
STRUCTURAL MATERIALS AND CLAY PRODUCTS.		8
Cement, natural rock	Brls. 124,400	91,870
" Portland	" 594,594	1,028,618
Granite		170,000
Pottery		200,000
Sands and gravels (exports)	Tons. 159,793	119,120
Sewer pipe		294,465
Slate		19,200
Terra-cotta, pressed brick, &c		348,597
Building material, including bricks, building stone lime, tiles, etc.		5,700,000
Total structural materials and clay products. . .		7,771,870
" all other non-metallic		21,248,094
Total non-metallic		29,016,964
" metallic		35,653,768
Estimated value of mineral products not returned ..		300,000
Total, 1902		64,970,732
1901, Total		66,712,708
1900 "		64,503,137
1899 "		49,584,027
1898 "		38,697,021
1897 "		28,661,430
1896 "		22,584,513
1895 "		20,648,964
1894 "		19,931,158
1893 "		20,635,082
1892 "		16,628,417
1891 "		18,976,616
1890 "		16,763,353
1889 "		14,013,913
1888 "		12,518,894
1887 "		11,321,331
1886 "		10,221,255

REMARKS.

Slight
decrease.

Notwithstanding the most gratifying increase in the total value of the production of non-metallic minerals, the grand total of the value of the production of all the mineral industries of Canada, shows a falling off of 2.61 per cent. This is due not merely to the decrease in the Yukon output of gold of \$3,500,000, but also to the very considerable falling off in values of all the remaining metallic minerals except nickel. But for the large growth of the coal and coke industry, helped by increases in many of the other non-metallic products, the decrease in the grand total, on account of the falling off in the metallic class would have amounted to nearly 10 per cent. The total of the metallic

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products, shows diminution amounting to over output 15 per cent, as compared with the equivalent figures for 1901, whilst the non-metallic class shows an increase of over 20 per cent in a similar comparison.

In regard to their relative importance, the metallic industries as a group, still occupy the most important place, although not leading to the extent they did in former years. They contributed about 55 per cent of the whole, the non-metallic following with nearly 33 per cent, and the structural class with nearly 12 per cent. Grouping the metal-liferous class with coal and coke, about 81 per cent of the value is accounted for.

Proportion of
metallics.

The following table gives the relative contribution to the grand total of the different mineral industries in comparison with 1901.

1901.		1902.	
Product.	Per cent of total Production.	Product.	Per cent of total Production.
1 Gold.....	36.17	1 Gold	31.92
2 Coal and coke	17.49	2 Coal	23.92
3 Copper.....	9.14	3 Building material....	8.47
4 Building material....	7.71	4 Nickel.....	7.74
5 Nickel	6.89	5 Copper	7.01
6 Silver	4.89	6 Silver	3.51
7 Lead	3.37	7 Coke	2.37
8 Asbestos	1.89	8 Asbestos	1.85
9 Coke	1.84	9 Cement.....	1.72
10 Pig iron (from Canad'n ore)	1.82	10 Iron ore (exports)....	1.64
11 Petroleum	1.51	11 Pig iron (from Canad'n ore)	1.61
12 Iron ore (exported)....	1.14	12 Lead	1.44
13 Cement.....	0.99	13 Petroleum.....	1.44
14 Gypsum	0.51	14 Mica.....	0.62
15 Natural gas	0.51	15 Gypsum.....	0.55

It will be noted that copper has fallen from third to fifth place; lead from seventh to twelfth. Iron ore exported has advanced two places, but pig iron from Canadian ore is now eleventh in importance, where last year it ranked tenth. Silver maintains its position, whilst nickel advanced to fourth.

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Increases and
decreases.

INCREASE AND DECREASE IN 1902.

Product.	Quantity.		Value.	
	Increase.	Decrease.	Increase.	Decrease.
	p. c.	p. c.	p. c.	p. c.
Metallic—				
Copper.....	3.54			21.99
Gold.....				14.04
Pig iron (from Canadian ore only).....		13.76		13.95
Pig iron (from both home and imported ores).....	30.44		20.80	
Lead.....		55.68		58.39
Nickel.....	16.37		9.39	
Silver.....		21.05		30.15
Arsenic.....	15.27		15.17	
Non-metallic—				
Asbestos and asbestic.....	0.55			3.67
Coal.....	22.67		29.43	
Coke.....	38.56		25.30	
Corundum.....	82.88		59.03	
Cement.....	59.64		69.76	
Gypsum.....	13.02		4.75	
Petroleum.....		16.21		7.29
Salt.....	6.10		10.01	

In studying the above table, it will be noted that the showing made by the metallic class as a whole is in great contrast with that exhibited by the non-metallic class. In the former case, although copper, pig iron as a whole, and nickel, were turned out in larger quantities than last year the beneficial results were modified or even reversed by the lower values obtained. In all the other metallics, the heavy falling off in production is markedly aggravated by the fall in values in these instances also.

Non
metallics.

In the non-metallic class, there is fortunately a better record. Only in the cases of asbestos, asbestic and petroleum do the values show decreases, whilst for all the other items the proportional growth is very marked. Although in several of the industries there has been a falling off in values, in others on the contrary, the increase has been very marked.

Iron smelting.

It will be noticed that although the output of pig iron from Canadian ore has fallen off, the whole iron smelting industry shows notwithstanding marked growth. Taking the values of the coal and coke produced during 1902, together with those in the allied iron smelting industry, an increase of nearly \$4,500,000 is exhibited, shewing a

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growth in these, the most commercially important industries of the country, more than offsetting the falling off of the \$3,500,000 in the necessarily fluctuating product of the placer gold washings of the Yukon territory.

The value per capita of the total mineral products compared with our population was \$11.87 in 1902, as against \$2.23 in 1886, the first year for which figures are available.

Viewing the different industries separately some of the more interesting features are given below :—

Copper.—Despite the drop in copper values during the latter months of 1901 and the continuation of low prices throughout 1902, an average of less than 12 cents per pound at New York, there was produced in Canada in 1902 nearly 20,000 tons of copper in ore, matte, etc., which was a slight increase over the output of the previous year. In the eastern part of Canada, perhaps, one of the most interesting features of this industry was the production of electrolytic copper by the Intercolonial Copper Company at their works in New Brunswick. The pyrites ores at Capelton, Quebec, are at present the chief source of copper production in this province, and the output varies but little from year to year. In Ontario the nickel-copper ores of the Sudbury district were worked to about the same extent as during the previous year. Extensive preparations, however, are being made, it is said, to push operations vigorously during 1903 and a largely increased output is confidently looked forward to for 1903. In British Columbia there was an increased production of copper. From the Rossland district about 350,000 tons of gold-copper ore were shipped to the smelters, while over 500,000 tons of the low-grade copper ores of the Boundary district were mined and shipped.

Important
features of
different
industries.

Gold.—The gold mining industry in Canada in 1902 shows no radically new features. The output of the Yukon placers continues to decrease, the output for 1902 being estimated at \$14,500,000 in the preliminary statement. This estimate is based on receipts at United States mints. Royalty was paid on gold officially valued at \$12,018,561. As, however, for the purposes of the royalty, the gold is arbitrarily valued at \$15 per ounce, and as much of the gold is really worth more than this, the actual value of the gold sent out of the country would necessarily be somewhat more than that represented by the royalty certificates. Then, again, some allowance will have to be made for gold in small amounts on which no royalty is payable, and on that smuggled out to avoid payment of royalty. Taking these

Gold.

various items into consideration it will probably be found that the above estimate of \$14,500,000 is not excessive. The output of the other established gold mining districts continues with practically the same results as during the previous year.

Iron.—The production of iron ore in Canada is not at present commensurate with the iron smelting interests of the country. The total quantity of Canadian ore used in Canadian furnaces was 125,664 tons, in addition to 539,381 tons of imported ore. The total quantity of pig iron made was 459,902 tons (of 2,000 lbs.) Of this product 237,244 tons were made in Nova Scotia in the furnaces of the Dominion Iron and Steel Company and the Nova Scotia Steel and Coal Company. Quebec furnaces contributed 7,970 tons, and Ontario furnaces at Deseronto, Hamilton and Midland produced 112,688 tons. The product of the Quebec furnaces at Radnor Forges and Drummondville and of the Deseronto furnace in Ontario, is charcoal pig iron, while coke is used as fuel in all the other furnaces.

The Clergue interests at Sault St. Marie have been erecting blast furnaces at that place, intended to use charcoal as fuel, but these have not yet been completed.

The manufacture of steel is rapidly becoming an important feature of Canada's metallurgical industries. Over 150,000 tons were made in 1902, valued at nearly \$3,000,000. A steel rail plant was completed and placed in operation at Sault Ste Marie. Continuous operation, however, has not been maintained so far.

Lead.—The quantity given in the above tables practically represents the contents of the ores produced from all the British Columbia mines. The output of 1902 has fallen off over 55 per cent as compared with the previous year. The silver output of this province has also suffered in sympathy with the lead, although not nearly to the same extent as explained under the heading silver.

Nickel.—The nickel industry exhibits, in 1902, but little change so far as quantity of production is concerned. This has already been referred to in connection with copper. In addition, it may be said that the ore smelted amounted to 211,847 tons, producing 23,211 tons of ordinary matte carrying an average of about 19.4 of nickel and 2,100 tons of Bessemer matte averaging 40.27 nickel. Besides the product sold by the Canadian Copper Co. and the Mond Nickel Co. a considerable tonnage of ore was mined by the Lake Superior Power Co. at the Gertrude and Elsie mines. The greater part of this was

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sent to the roast heaps, a small portion going to the reduction works at Sault Ste. Marie.

Silver.—Although British Columbia is the chief silver-producing province of the Dominion, small quantities have, as usual, been produced from some of the other well-known districts, viz., that obtained as a by-product from the pyrites ores near Capelton, Quebec, that from the mines in Thunder Bay district, Ontario, and the silver found in association with the placer gold of the Yukon Territory. In British Columbia there was a falling off in the production. The general conditions affecting this industry have already been referred to in part in treating of the lead product. The ores of the Rossland and Boundary districts, however, carry appreciable quantities of silver and an increase in the production of these ores has to some extent offset a decrease in the output of the silver and silver-lead ores.

Zinc.—The production of zinc as given in the preliminary summary table of mineral production was all derived from a newly opened mine in the township of Olden, Frontenac county, Ontario. Although no statistics of zinc ores in the province of British Columbia are as yet available, there appears to have been some demand during the year from the United States for zinc ores from this province, and several shipments are reported as having been sent to Kansas.

Coal.—Amongst the non-metallic minerals coal is by far the most important. It contributed in 1902 nearly 24 per cent of the total mineral production in Canada, being exceeded only by gold, and shows an increase of more than 22 per cent over the output of 1901. Coal-mining operations were especially active in Nova Scotia, where the coal sold during the year amounted to 4,229,120 long tons. Of this amount over 33 per cent was sold within the province, over 40 per cent found a market in New Brunswick, Prince Edward island, Quebec, etc., while the balance was exported, chiefly to the United States.

The average value placed upon the coal product of this province at shipping points on the authority of Mr. C. Shields, vice-president of the Dominion Coal Company, was \$2 per long ton. There has been a considerable demand in adjacent portions of the United States for Nova Scotia coal, intensified no doubt by the stringency in the supplies of anthracite coal due to the long strike of the anthracite miners in Pennsylvania. The action of the United States government in removing the duty for the period of one year on bituminous coal entering that country will probably result in largely increased shipment

Demand for
Nova Scotia
coal.

of Nova Scotia coal in that direction. A substantial increase was made in the output of coal from the North-west Territories from the well established mines at Souris and Roche Percé, Lethbridge, Anthracite, Canmore, Frank and from the many small mines in the Edmonton district.

The Crow's Nest Pass Coal Co. continued to develop their properties. They did not however, owing to an unfortunate explosion in May, 1902, and several subsequent strikes, materially increase their output.

The production of the Vancouver Island collieries was somewhat less than during the previous year. -

A largely increased quantity of coke was made during 1902 to meet the requirements of smelting operations.

Other Non-metallic Minerals.—Amongst other non-metallic minerals important increases are shown in *arsenic*, *corundum*, *cement* and *gypsum*. Arsenic was produced to the extent of 800 tons, valued at \$48,000. This output is of interest as being the only production of arsenic on this continent. The asbestos mining industry of the eastern townships, Quebec, exhibits but little change from the previous year, the output of 1902 being valued at \$1,203,452.

Corundum production shows an increase of over 80 per cent compared with 1901. This industry, although only commenced in 1900, is showing a strong and steady growth. The output is derived from the Craig mine in the township of Raglan, Renfrew county. The Ontario Corundum Company has also begun operations in the township of Carling, Hastings county.

Other mineral
products.

Much might be written with regard to numerous other mineral products, but these hardly call for special mention at the present time, with the exception perhaps of Portland cement. A good deal of energy has been displayed during the past two years in the establishment of mills for the manufacture of Portland cement from marls and clay, &c., chiefly in the province of Ontario. There were eight Portland cement works in operation during 1902 as compared with four in 1901. The capacity of the works in operation in 1902 was about 3,000 barrels per day, while one mill with a capacity of 1,000 barrels per day was almost ready for operation at the close of the year, making the total capacity of Portland cement works already in operation at the beginning of 1903 about 4,000 barrels per day. The total quantity of Portland cement made in 1902, was 526,335 barrels, while the sales were 558,594 barrels. Stock in manufacturers' hands on the 1st January, 1902, were 65,705 barrels, and at the close of the year 33,446 barrels.

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Imports of cement during six months ending December, 1902, were Cement. 1,255,495 cwt., or about 313,874 barrels, valued at \$482,915.

In the general statement of the mineral production for the year, as contained in the summary of the mineral production of Canada in 1902 (subject to revision), the metallic production is given in terms of fine metal contained in ore, matte, etc., and valued at the final market value of the metals in some standard and recognized market. This has been considered as the most satisfactory method for the purpose of a general statement and for use in comparison with past years and with other countries. Such compilation, however, does not make any less useful or interesting a statement of the production of raw ores during the year, although to give a fair monetary value to the raw materials as shipped from the various mines, would be a matter of no small difficulty.

Manifestly the materials representing the first product as shipped from the works or mines will represent various and changeable values. For instance, of the different districts contributing to the output of copper, some produce raw ore and some partially finished products of processes of extraction. Confusion also arises from the fact that the values of given ores, etc., depend upon the presence of other constituents.

Then the spot values, depending as they do upon the extent to which extraction processes have been carried, are not only not comparable from year to year, owing to changes in practice, but the differences in condition and value between these varying sources of the same metal are such as almost to necessitate their separation into different classes.

In British Columbia, according to the annual report of the provincial mineralogist the tonnage of metalliferous ores mined was as follows by districts:

	Tons.
Grand Forks, Kettle River and Osoyoos Division	521,402
Roseland	329,534
Nelson	77,810
Slocan and Ainsworth	26,062
Coast	31,802
East Kootenay	3,881
Other districts	8,478

998,969

Ontario produced iron ore, nickel, copper ores, gold quartz, etc., to the extent of about 725,000 tons.

In Quebec the pyrites ores of Sherbrooke, though worked primarily for sulphuric acid, may, owing to their copper and silver contents, be classed as metalliferous. These, with iron ores and galena, and including the copper ores of New Brunswick, might account perhaps for about 60,000 tons in 1902.

METALLURGY.

Work by Mr.
Donald
Locke.

In October it was decided to employ Mr. Donald Locke, a graduate of Freiburg School of Mines, as metallurgist and assayer. On October 21 Mr. Locke left Ottawa for Sudbury with instructions to make a short report on the copper-nickel smelting processes of the Canadian Copper Company, the Ontario Smelting Works at Copper Cliff, and the Mond Nickel Company at Victoria Mines.

He was engaged in making the necessary examination of the various processes till November 4 when he returned to Ottawa. His summary report is as follows:—

Canadian
Copper Com-
pany's works.

At the Canadian Copper Company's works there were, at the time of my visit, eight Herreshof blast furnaces in operation, each smelting about 130 tons a day. The ore, which is heap-roasted, is practically self fluxing, only a small quantity of quartz being added. It contains about $1\frac{1}{2}$ per cent copper and $2\frac{1}{2}$ per cent nickel. Each furnace produced nearly 13 tons of matte containing about 12 per cent copper and 22 per cent nickel. The matter is tapped at intervals from the forehearth and when cold is broken and sent to the Ontario Smelting Works for concentration. The slag flowing continuously from the forehearth is granulated in McArthur granulating troughs. It assays about 0.27 per cent copper, 0.40 per cent nickel, 32 per cent silica and 40 per cent iron.

An experimental plant is in course of erection to see what can be done in the way of smelting pyritically. It is hoped to reduce the coke consumption to 3 or 4 per cent of the charge by using a hot blast and an oxydizing atmosphere in the furnace and utilizing the heat developed by the burning of the sulphur and iron of the ore.

The Ontario Smelting Works were concentrating the matte from the Canadian Copper Company to a matte containing 25 to 30 per cent copper and 50 to 55 per cent nickel.

Concentration
of matte.

The matte arriving from the Canadian Copper Company is reduced to a fine powder and roasted in Brown straight-line calciners, reducing the sulphur from 25 to 30 per cent down to 5 to 8 per cent. The

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roasted matte is smelted in two Oxford furnaces, being put through in the powder with quartz tailings and some roasted ore. Matte and slag are separated in the Oxford siphon-tap forehearth whence they flow in continuous separate streams into cast iron slag pots; the matte is sent to the Oxford Company, N.J., for the separation of copper and nickel, and the slag returns to the Canadian Copper Company's works where it is resmelted to extract the nickel and copper it contains.

The Mond Nickel Company at Victoria mine treats the ore from its own mine, producing a concentrated matte with about 80 per cent copper and nickel and $\frac{1}{2}$ per cent iron: this is sent to Clydach, Wales, to be treated there by the Mond process for copper and nickel. Mond Nickel Company.

The heap-roasted ore is brought to the smelter by an aerial tramway and tipped into bins above and behind the blast furnace feed floor.

The ore, assaying about 2.5 to 3 per cent copper and about 3 per cent nickel, is smelted in rectangular, steel waterjacketed furnaces 12 feet high and 44 inches by 120 inches at the tuyeres; the two furnaces (only one runs at a time) have each 16 tuyeres, 8 on each side, a water-cooled cast iron tap jacket and Hixon slag spout. One furnace puts through about 170 tons a day. The charges are dumped directly from the dump cars into the furnace through the open top, alternate charges being fed to the sides by means of a simple device consisting of a wrought iron pipe about 8 inch diameter, the length of the furnace opening, and let down about three feet into the furnace; on this the charge falls and is deflected towards the sides.

The blast is pre-heated by leading the air from the blowers through a channel built above the dust flue and separated from it by a steel diaphragm, thus utilizing the waste heat of the furnace gases.

The forehearth is of boiler iron, 9 feet in diameter and 3 feet 6 inches high, with a 6-inch lining of fireclay and quartz; from the forehearth the slag flows continuously and is granulated by a powerful stream of water.

The matte is tapped periodically and flows into the converters, which are situated on the lowest level of the smelter. About 20 tons of matte are produced per day by one furnace, assaying about 13 per cent copper and 15 per cent nickel.

In the converter department are six horizontal converters of the modified leghorn type, only one of which is in use at a time, the others Converters.

being repaired, lined or dried; the converters are 6 feet 8 inches in diameter and 7 feet long: they rest on roller wheels supported by a strong cast-iron frame and are revolved by a vertical rack bar extended downward into a hydraulic cylinder and geared with a toothed wheel attached to the converter. The first charge of a newly lined converter is only about one ton, but as the lining is eaten the size of the charge increases, the average charge being about two tons—a lining lasts 11 to 12 hours, about six charges being blown in this time; a blast of 10 lbs. pressure is employed; the concentrated matte contains about 80 per cent nickel and copper—when cold it is crushed and packed in barrels to be sent to Wales for further treatment. The converter slag is put through the blast furnace to recover its metal contents.

MAPPING AND ENGRAVING.

Mr. C.-O. Senécal, Geographer and Chief Draughtsman.

Report of
geographer
and chief
draughtsman.

Mr. Senécal reports as follows on the work accomplished under his supervision during the calendar year 1902:—

Staff.

As usual the field assistants who attend to mapping during the winter months left early for the field, and from June to October, the office work was carried on by only a few draughtsmen. Although the progress was satisfactory, this staff is still insufficient to keep pace with the increasing demands made on this office. One or two good map draughtsmen are required to compensate for the assistants who are regularly detached for field-work and who necessarily have to devote considerable time to the preparation of their returns. The intermittent delays in the compilation of some of the maps could, in a measure, be thus avoided.

Routine work.

The general work of laying down geographical projections for new maps, correcting report and map proofs, preparing memoranda on various subjects for the information of the director, the librarian and correspondents, auditing map accounts, collecting and listing instruments for repairs, making office and field tracings, blue-prints, distributing printed maps, etc., was attended to. In this connection it is also desirable to obtain the services of a general office assistant, whose duty would be to attend to the cataloguing of survey records, manuscript sheets and other documents, do typewriting and general draughting. At present, this work which also includes the care and distribution of field instruments, devolves upon the draughtsmen and it is the cause of much delay in the regular map work, while I am

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constantly under obligation to the typewriters of the other sections of the department, for copies of map specifications, letters, etc.

The work has been distributed as follows:—

Mr. L. N. Richard has completed the compilation of the Bancroft map and has drawn the same for engraving. He has prepared the colour copy of the Manitou sheet—sheet No. 4, Western Ontario—has compiled and drawn for engraving the map of Shefford mountain: has traced the greater part of Perth sheet—sheet No. 119, Ontario—for engraving: has made several zinc-cut drawings for various reports and has spent some time in tracing plans of new surveys, correcting map-proofs, etc. Mr. Richard has now in hand a general index-map of the Dominion, showing the progress of the Geological Survey to the present time.

Assignment
of work

Mr. W. J. Wilson has, for the greater part of the time spent in the office, been engaged on the compilation of the Ontario sheets Nos. 143 and 156 covering the Michipicoten mining district. His surveys, as well as those of Dr. R. Bell made in that region have all been reduced to the scale of publication, but before final adjustment can be made on the sheets, certain plans of surveys of the Ontario government and of the Algoma Commercial Co., are required. As soon as these plans will have been received the sheets will be promptly finished.

Mr. Wilson, accompanied by Mr. O'Sullivan, left for the field at the end of May, to explore new country in Keewatin district. Since his return, he has been engaged in compiling a map of this exploration for the present Summary Report. Mr. Wilson also spent some time plotting, etc., and writing his report.

Mr. J. F. E. Johnston has completed the compilation of the topographical map of the Klondike mining region and has prepared lists and memoranda of repairs of instruments. He has completed and filed the plotted sheets and note-books of his surveys of 1899 to 1901 and left for the field with Dr. Alfred W. G. Wilson of Montreal, for an exploration of the country north of Lac Seul, Keewatin. Since his return, Mr. Johnston has plotted part of his work, and began the compilation of a map for this year's Summary Report. He is at present on sick leave.

Mr. O. E. Prud'homme has drawn and lettered for engraving, the plans of Lake Catcha, South Uniacke, and Tangier gold districts, Nova Scotia; the sheets Nos. 59, 60, 61 and 62 of the Nova Scotia series and the map of Klondike mining region. He has pre-

pared the lithographer's copy, (crayon shading) for the topographical edition of the West Kootenay sheet, B.C.; has drawn several zinc-cut illustrations for geological reports, and has drawn for photolithographing the Orographic map of Turtle mountain, Manitoba, and a section of Blue-nose gold mine, Nova Scotia.

Distribution
of printed
maps.

Mr. Prud'homme has, as usual, attended to the distribution of the printed maps held for sale and distribution. I may here remark that the time spent on this work—which does not properly belong to my office, and is the cause of much delay in Mr. Prud'homme's regular work,—is very considerable, and I would suggest that the stock of printed maps be placed under the direct control of the librarian, and the draughtsman relieved of the distribution.

Mr. J. Keele has completed the compilation of sheets Nos. 119 and 122, Ontario and Quebec series, and spent some time in plotting surveys made by Dr. A. E. Barlow, in Sudbury district, Ontario. He left for the field on June 4, as topographer for Mr. R. G. McConnell, and surveyed the Pelly and MacMillan rivers and tributaries for about 500 miles. He returned to the office on October 17, and has since compiled and drawn a map of the above explorations for the Summary Report.

Mr. W. H. Boyd has assisted Mr. D. B. Dowling in compiling the final map of Ekwan and Trout rivers, Keewatin district; has prepared an office index-map of the various explored fields of the Yukon Territory, and spent most of his time in plotting and putting in shape Mr. R. W. Brock's surveys of 1901. He accompanied this officer in the field last summer as topographer from June 29 to October 10, and surveyed part of the Boundary mining district, British Columbia. He is at present reducing and compiling his data for publication.

Mr. J. A. Robert has continued the compilation of Mr. H. Fletcher's surveys on sheets Nos. 64, 65, 73, 76, 77, 78 and 81 of parts of the counties of Cumberland, Colchester and Hants, Nova Scotia. He has prepared the colour copy for sheets Nos. 44 to 48 and 56 to 58, Nova Scotia; has traced part of sheets Nos. 59 and 60, Nova Scotia, for engraving; has corrected map-proofs and made a large number of tracings of plans of new surveys for the Nova Scotia sheets.

He compiled, from recent data, additions to Mr. H. M. Poole's map of Pictou coal-fields which will shortly be in shape for publication.

Mr. Robert has also prepared a set of drawings for colour patterns for geological sheets and the model of a protractor plotting sheet for copper plate engraving.

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He is at present tracing a map of Springhill coal-fields for the Summary Report.

Mr. O. O'Sullivan has almost completed the compilation of the topography on sheets Nos. 54, 67, 68 and 69, Halifax county, N.S., and has traced several plans for office and field use. He left for the field with Mr. W. J. Wilson on May 24, and since his return has plotted his summer's work for the Summary Report, and resumed the compilation of Mr. E. R. Faribault's surveys on sheets 67 to 71, N.S.

Mr. P. Frèreault has compiled additions to Grenville sheet,—sheet No. 121, Ontario and Quebec,—and to the three sheets of Mr. A. P. Low's map of the east coasts of Hudson Bay and James Bay. He has made tracings and colour copy for the printing of the above maps, as well as for the West Kootenay sheet, the east Kootenay map, B.C., and the Victoria Mines map, Sudbury District, Ont.

Mr. Frèreault spent some time on sheets Nos. 16 and 17, Nipigon district, Ont.; prepared a list of Hudson Bay and Ungava District names for the Geographic Board, and attended to general draughting work.

Mr. V. Perrin has been engaged with Mr. McInness, in plotting this officer's surveys covering Ignace sheet—No. 5, Western Ontario series—has traced a portion of sheet No. 59 N.S. for engraving, and attended to general work, cataloguing plans and maps, &c. He has drawn for photo-lithographing a map of the Gaspé oil-fields, Quebec.

The following maps have been compiled by field officers from their respective surveys:—

Map of Ekwan and Trout rivers, Keewatin, scale 8 miles to 1 inch,* and Orographic map of Turtle mountain, Manitoba, scale $1\frac{1}{2}$ miles to 1 inch, by Mr. D. B. Dowling.

Plans of the following Gold districts of Nova Scotia, by Mr. E. R. Faribault:— Mapping by
field officers.

Isaacs Harbour, Guysborough county, scale 500 ft. to 1 inch.

Cochrane Hill, Guysborough county, scale 500 ft. to 1 inch.

Wine Harbour, Guysborough county, scale 400 ft. to 1 inch.

Harrigan Cove, Halifax county, scale 400 ft. to 1 inch.

Tangier, Halifax county, scale 250 ft. to 1 inch.

* This map has been incorporated in map No. 814, which accompanies the present Summary Report.

South Uniacke, Halifax county, scale 250 ft. to 1 inch.

Lake Catcha, Halifax county, scale 250 ft. to 1 inch.

Montague, Halifax county, scale 250 ft. to 1 inch.

Gold River, Lunenburg county, scale— ft. to 1 inch.

Geological sketch map of the Blairmore-Frank coal-fields, Alberta, scale 180 chs. to 1 inch, by Mr. W. W. Leach.

Dr. A. E. Barlow compiled his surveys of the Sudbury mining region on a scale of 40 chains to 1 inch. His map which consists of two sheets, has however been prepared in this office for engraving and printing on the scale of 1 mile to 1 inch. The Victoria Mines portion has been engraved, and the Sudbury sheet is almost ready for engraving.

Another map of part of Sudbury district,—the map of Copper Cliff Company's mines, of a special character, is also under preparation by Dr. Barlow.

New surveys of the chains of islands along the east coast of Hudson bay, have been supplied by Mr. A. P. Low, and incorporated in his map.

Nova Scotia
sheets.

The following sheets of the set of geological sheets of Pictou and Colchester counties, N.S., upon which the engravers resumed work last March, after having been for a long time held back on account of certain geological points requiring final investigation, were received from the King's Printer, namely :—Sheets Nos. 43, 44 and 45.

Sheet No. 57 has been signed for printing, and there still remain sheets 46, 47, 48, 56 and 58 in the hands of the printer, but it is hoped that most of these will be received within a short time.*

Dominion
map.

The edition of the western half of the general geological map of the Dominion has been issued and distributed. It is only on the 8th of August, however, that the map could be delivered to this department, the lithographer, in December, 1901, notwithstanding previous delays and without the knowledge or permission of this department, having wiped off all the colour stones, had to spend considerable time in doing this work anew.

The colour copy for the eastern half of this map is in progress.

* Since writing the above, the remaining sheets have been received from the printer.

SESSIONAL PAPER No. 26

The regular meetings of the Geographic Board have been attended and lists of names covering the east coasts of Hudson Bay and James Bay, the northern interior of the Labrador peninsula and the Grenville sheet (sheet 121, Ont. and Que.) have been prepared and submitted to the board for discussion and decision. Another list of a few hundred names for sheets Nos. 59 to 62, Nova Scotia, is also under preparation.

Geographic Board.

The following ten maps accompany the present Summary Report and illustrate part of the progress made in the field during the past summer :—

Accompanying maps.

No. 810.—The Dominion of Canada, showing the progress of investigation by the Geological Survey of Canada, 1843 to 1903. Scale 250 miles to 1 inch.

No. 805.—Yukon Territory.—Explorations on MacMillan, Pelly and Stewart rivers. Scale 8 miles to 1 inch.

No. 808.—Alberta District.—The Blairmore-Frank coal-fields. Scale, 180 chains to 1 inch.

No. 804.—Manitoba.—Orographic map of lower contour of Turtle mountain. Scale, $1\frac{1}{2}$ miles to 1 inch.

No. 809.—Ontario.—Shore lines of Ancient Great Lakes. Scale, 24 miles to 1 inch.

No. 814.—Ontario and Keewatin.—Explorations south-west of James bay. Scale, 16 miles to 1 inch.

No. 802.—Quebec.—Sketch map of Gaspé oil-fields. Scale, 2 miles to 1 inch.

No. 812.—Nova Scotia.—Preliminary Geological map of Springhill coal-field. Scale, 50 chains to 1 inch.

No. 806.—Nova Scotia.—Transverse vertical section of Blue-nose gold mine.

No. 801.—Prince Edward Island.—Geological outline map of P. E. Island, showing anticlines. Scale, 16 miles to 1 inch.

Maps, etc.,
published.

A list of maps, plans, diagrams, etc., which have been received from the printer during the calendar year, is appended herewith:—

Catalogue Number.	Description.	Area in Square Miles.
783	General geological map of the Dominion of Canada—Scale, 50 miles to 1 inch (western sheet).	
742	British Columbia—Geological and topographical map of Atlin mining district—Scale, 4 miles to 1 inch	814
771	" —Geological and topographical map of a portion of East Kootenay district—Scale, 4 miles to 1 inch. Preliminary edition ..	4,958
767	" —Geological and topographical map of Crows Nest coal-fields—Scale, 2 miles to 1 inch. Preliminary edition.....	
766	Saskatchewan, Athabaska and Keewatin—Geological map of a portion of these districts (Grass river map)—Scale, 8 miles to 1 inch	41,360
777	Quebec—Geological and petrographical plan and sections of Shefford mountain, Shefford Co.—Scale, 40 chains to 1 inch.	47
785	Ungava—Sketch map of northern portion of Labrador peninsula—Scale, 50 miles to 1 inch. Corrected edition of map No. 758.....	
598	Nova Scotia—Sheet No. 43 (Stellarton sheet), Pictou Co.—Scale, 1 mile to 1 inch	216
600	" Sheet No. 44 (New Glasgow sheet), Pictou Co.—Scale, 1 mile to 1 inch.....	216
	" Sheet No. 45 (Toney river sheet), Pictou Co.—Scale, 1 mile to 1 inch.....	216
765	" Lake Catcha gold district, Halifax Co.—Scale, 250 feet to 1 inch.....	
768	" South Uniacke gold district, Hants and Halifax Cos.—Scale, 250 feet to 1 inch..	
	Also seven diagrams to illustrate the Mineral Production of Canada, and seven zinc-cut illustrations for report No. 797, a special publication on the Cambrian Rocks of Cape Breton island.	

Maps in
progress.

Besides the maps accompanying the Summary Report, 1902, there are nineteen maps in the hands of the King's Printer, and about thirty-five more, the compilation of which is at various stages of progress.

Field instru-
ments.

The examination and repairing of field instruments has been attended to. Several worn-out prismatic compasses, tapes, barometers, etc., have been replaced. The following instruments were purchased:—

SESSIONAL PAPER No. 26

One microscope, No. 6, with attachments and set of objectives, from R. Fuess, Stiglitz, Germany. Field instruments.

Four prismatic compasses and tripod heads, Nos. 67-70, from Cary, London, Eng.

Five surveying aneroid barometers, Nos. 64-68, from Harrison & Co., Montreal.

Six pocket clinometer-compasses, Nos. 1-6, from Keuffel & Esser Co., New York.

One telescope for solar compass, No. 11, from W. & L. E. Gurley, Troy, N.Y.

Eight pocket compasses, Nos. 33-40, from T. Shore, Ottawa.

Eight pocket thermometers, Nos. 20-27, from Keuffel, & Esser Co., New York.

Two 100-ft. Chesterman metallic tapes, from Department of Stationery, Ottawa.

One 25-foot Chesterman metallic tape, from Department of Stationery, Ottawa.

Six taffrail boat logs, from G. Ashton Kay, New York.

One 50 foot steel band, No. 25, from Keuffel & Esser Co., New York.

The number of official letters, specification sheets, memoranda, etc., sent and received was 344 and 204 respectively. Correspondence.

PALEONTOLOGY AND ZOOLOGY.

Dr. J. E. Whiteaves.

Dr. Whiteaves reports that the manuscript of part V, of volume I, of 'Mesozoic Fossils,' which was commenced in September, 1901, was completed on November 5, 1902, and that an index to the whole volume has subsequently been prepared. This part, which it has taken the greater part of three weeks to see through the press, as now printed, consists of 107 pages royal octavo of letter-press, illustrated by thirteen text figures and twelve full-page lithographic plates. Its preparation has necessitated the examination and critical study of seven additional collections from the Cretaceous rocks of Vancouver, Texada and Lasqueti islands, kindly forwarded by Mr. Harvey of Nanaimo, V.I. For the description of seven of the ten species of crustacea enumerated and illustrated in it, the writer is indebted to the kindness of Dr. Henry Woodward, F.R.S. The volume of which it forms the concluding part, now consists of 416 pages of letter-press, illustrated by twenty-nine text figures and fifty-one lithographic

plates. It may be described as a series of illustrated papers on the fossils of the Cretaceous rocks of the Vancouver and Queen Charlotte islands, in which 252 species are either identified or described.

A preliminary study has been made of the rather extensive collections of fossils from the Silurian rocks of the Ekwan river and Sutton Mill lake, made by Mr. D. B. Dowling in 1901, and a paper descriptive of two new species of *Trimerella* from these rocks has been published in the 'Ottawa Naturalist' for October last. About fifty species of marine invertebrata are represented in these collections, most of which are apparently new to science.

The collections of fossils made last summer, by Mr. D. B. Dowling, from the Laramie deposits near Roche Percée, Assiniboia, of fish remains from the supposed Niobrara shales at Arnold, Manitoba, and from the Silurian limestone at Stonewall, Manitoba; and those made by Mr. W. W. Leach, from the Laramie and Cretaceous rocks of the Old Man river, Alberta, have been subjected to a preliminary examination, and their geological horizons approximately indicated.

The collections of fossils made last summer by Dr. R. A. Daly from the Paleozoic rocks at different localities in the Chilliwak river valley, have been studied, and some notes on these fossils have been prepared for Dr. Daly.

Collections of fossils, from the Devonian rocks of the Kwataboahagan, Moose and Abitibi rivers, and from the Pleistocene deposits at eight different localities on the Kapiskau, Kwataboahagan and Abitibi rivers, made by Mr. W. J. Wilson last summer, have been examined, and a list of the species represented in them has been supplied, for incorporation in his forthcoming report.

Seven small consignments of fossils from the Corniferous limestone near Amherstburg, Ontario, forwarded by the Rev. Thomas Nattress, have been studied, and the species represented in them have been named as far as practicable. One of these species, which apparently belongs to the genus *Panenka* of Barrande, and to a previously uncharacterized species of that genus, has been described and figured in the 'Ottawa Naturalist' for March last. It is the second species of *Panenka* that has been recognized in the Devonian rocks of Canada.

A preliminary examination and study has been made of a large series of fossil Cephalopoda from the Birdseye, Black river and Trenton formations at several localities in the immediate neighbourhood of Ottawa, kindly forwarded by Mr. Walter R. Billings.

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A few fossils from the country south of Abitibi lake (apparently from small boulders), and from near Fernie, B.C., have been examined and some notes on them forwarded to the senders.

In September last eight days were spent with Dr. Ellis in examining some rock exposures near Brockville, on Howe island, at Rudd's quarry, near Kingston, and at the cutting of the Grand Trunk railway near Kingston Mills. At this latter locality quite an interesting little collection of fossils was made, including some specimens showing the posterior apical termination of an apparently undescribed species of *Nanno*. These fossils would seem to show that the geological horizon of the rocks from which they were obtained is that of the lowest part of the Black River formation underlying the limestone. The paleontological and zoological collections in the museum of Queens University, Kingston, were also examined, as were also the private collections of fossils, etc., of Mr. Werden at Cherry valley, near Picton, and of Mr. Chadd, at Trenton. In the museum of Queens three specimens of the typical '*Lituities undatus*,' (Emmons) were noticed, and one of these has since been acquired for the museum of the Survey.

At the request of Section IV. of the Royal Society of Canada, a bibliography of Canadian Zoology for the year 1901 has been prepared and presented at its last meeting, for publication in its transactions.

Six short papers, descriptive of some of the latest additions to the zoological collections in the museum, have been written and published in the '*Ottawa Naturalist*' for February, June, July, October and November, 1902.

About the usual number of letters, asking for information upon paleontological, zoological and other topics, have been received and answered.

The following specimens have been received from members of the staff, or employees of the department, during the year 1902 :—

Hugh Fletcher :—

Five specimens of fossiliferous shale from Messenger brook, near Kingston station, N.S.

Dr. R. W. Ellis and J. F. Whiteaves :—

Two small collections of fossils from Ontario : one from Rush bay, Howe island, and the other from the railway cutting at Kingston Mills.

Dr. H. M. Ami :—

About fifty specimens of fossils from the Pleistocene concretionary nodules at Besserers, near Ottawa ; and one specimen of *Trocholites Canadensis*, Hyatt, from the Black River limestone at the Montmorency river, P.Q.

D. B. Dowling :—

Forty fossils from the Lignite Tertiary at Roche Percée, Assiniboia : thirty from the Cretaceous rocks at the Pembina river, Manitoba : seventeen from the Niobrara shales at Arnold, Manitoba : and twenty from the Silurian (Upper Silurian) rocks at Stonewall, Manitoba.

W. J. Wilson & O. O'Sullivan :—

110 fossils from the Devonian rocks of the Kwataboahagan and Abitibi rivers, and Piskwochi point, James bay.

Twenty specimens of fossil plants from the Pleistocene deposits of Abitibi river, and 165 Pleistocene fossils from the valleys of the Kapiskau, Kwataboahagan and Abitibi rivers.

W. W. Leach :—

Twenty five specimens of fossil shells and six of fossil plants from the Laramie and Cretaceous rocks of the Old Man river, Alberta.

W. Spreadborough :—

329 birds and small mammals from the boundary region between the Kettle and Columbia rivers. B.C.

The additions to the paleontological, zoological, ethnological and archaeological collections in the museum during 1902 and from other sources are as follows :—

By presentation :—

(A.—Paleontology.)

Col. C. C. Grant, Hamilton, Ont.:—

Twenty-nine fossils from the Silurian rocks at Hamilton, five from the drift of Winona, and two from the drift at Burlington Heights.

T. C. Weston, Quebec City :—

Fossil coral (*Tetradium fibratum*) from Lorette falls, P.Q.; one specimen each of *Lingula Quebecensis*, Billings, and *Elkania desiderata* (Billings) from Point Levis, P.Q.

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M. P. Davis, Ottawa :

Specimens of fossil wood from excavations in the bed of the St. Lawrence river, in caisson for south main pier of the Quebec Bridge, Victoria cove, Sillery. Also samples of the materials from different depths and portions of the caisson of the same pier.

Rev. Thos. Nattress, Amherstburg, Ont. :—

Cast of the interior of the body chamber of a large specimen of *Gyroceras Numa*, Billings, from the Corniferous limestone near Amherstburg.

J. E. Narraway, Ottawa :—

Small piece of Black river limestone from Tetreauville, P.Q., with four heads of *Ilænus angusticollis*.

Lawrence J. Burpee, Ottawa :—

Fossil plant (? *Lepidodendron clypeatum*, Lesquereux) and piece of fossil wood (*Cordaites materioides*, Penhallow) from Casey point, Shediac bay, N.B.

Daniel McKenzie, Fernie, B.C. :—

Eight specimens of fossiliferous limestone from near Fernie.

David Armit (per D. B. Dowling) :—

Specimen of *Spirifer pennatus*, Atwater (= *S. mucronatus*, Conrad) from the Albany river shales.

(B.—Zoology.)

J. J. Carter, Ottawa :—

Flying squirrel, from Mariposa township, Victoria county.

W. S. Odell, Ottawa :—

Star-nosed mole, and two weasels, in summer fur, all from Ottawa East.

Rev. C. J. Young, Sharbot lake, Ont. :—

Male Arctic three-toed woodpecker, from near Sharbot lake.

Nest and set of four eggs of the Maryland yellow-throat, from near Lansdown, Ont. ; and set of three eggs of the Herring Gull, from Pine lake, County Frontenac, Ont.

Edwin Beaupré, Kingston, Ont. :—

Female black-breasted plover, from Amherst island, and photos.
of the nesting places of four species of Canadian birds.

Set of five eggs of the American Bittern, from Cataraqui Marsh;
and abnormally small egg of the Kingbird, from Napanee.

R. W. Tufts, Wolfville, N.S. :—

Two full sets of eggs of the house sparrow, and two of the barn
swallow, from Wolfville.

A. P. Low :—

Specimen of the Hudson Bay Lemming (*Dicrostonyx Hudsonius*)
from the east coast of Hudson bay.

David McFarlane, Sand point, Ont. :—

Black chipmunk taken at Norway Bay Park.

Lawrence Watson, Charlottetown, P.E.I. :—

Five small pieces of red sandstone with burrows of *Petricola*
pholadiformis.

L. M. Lambe, Ottawa :—

Little brown bat (male) from Ottawa.

W. E. Saunders, London, Ont. :—

Sixteen specimens of Unionidae from Chatham, Ont.

J. Smith, Ottawa :—

Ball of Buffalo hair (probably from stomach of buffalo) found in
prairie at Alberta, by J. E. Woods.

(C.—*Ethnology and Archaeology.*)

R. W. Brock, Kingston, Ont. :—

Two stone pestles from the north fork of Kettle river, B.C.

A. P. Low, Ottawa :—

Twenty-five specimens of arrow heads, spear heads, chipped flints,
sound, east coast of Hudson bay.
and fragment of a stone lamp, from ancient camps, Hopewell

Alfred Stirton, Spencerville, Ont. :—

Ten specimens of fragments of pottery and bone implements from
Indian graves and mounds, about two and a half miles east
of Spencerville, found eighteen inches below the surface of
the ground.

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G. B. Greene, Ottawa :—

Stone pipe bowl, with a carved figure of bird found on the south side of the Ottawa river, opposite Aylmer.

T. C. Weston, Quebec City :—

Four bullets from the Plains of Abraham.

Dr. C. F. Newcombe, Victoria, B.C. :

Two water-colour sketches of Chief Weed's house at Masset, B.C., by W. Chapman.

By exchange :—

Fine specimen of *Eurystomites* (?) *undatus* (Emmons), from the Black River limestone at Kingston.

By purchase :—

Two specimens of the Golden Eagle from near Kingston, Ont.

Two full sets of eggs of the Golden-crowned Kinglet, and one set each of the Northern American Raven, Rusty Blackbird, Acadian Sharp-tailed Sparrow, and Red-breasted Nuthatch ; all from Nova Scotia.

PALEONTOLOGICAL WORK.

Mr. Lawrence M. Lambe.

Mr. Lawrence Lambe reports as follows :—

The first half of the year was spent in a continuation of the study of the vertebrate fauna of the Belly river series of the Cretaceous of the North-west as represented, principally, by my collections in the Red Deer River district in 1897, 1898 and 1901.

The result of this study, begun in 1900, in co-operation with Professor Henry Fairfield Osborn, appeared early in September in the form of a memoir : ' On vertebrata of the Mid-Cretaceous of the North-west Territory,' forming the second part of volume III (quarto) of Contributions to Canadian Palaeontology.

Publication of memoir on vertebrates.

This memoir, following the late Professor Cope's first part on ' The species from the Oligocene or Lower Miocene beds of the Cypress Hills,' is descriptive of the fauna of the Belly river series that includes fishes, batrachians, reptiles and mammals. It consists of an introductory section by Professor Osborn on the ' Distinctive charac-

Description of a new cretaceous fauna.

ters of the Mid-Cretaceous Fauna', followed by a descriptive section by myself on 'New Genera and Species from the Belly river series (Mid-Cretaceous)' illustrated by numerous text figures and twenty-one plates.

The general conclusion regarding the age of the Belly river fauna, as expressed by Professor Osborn, is that it 'is more ancient in character both as to the elder types of animals which it contains and as to the stages of evolution among animals which are also represented in the Laramie. The geological interval represented by the Ft. Pierre-Fox Hills marine beds was accompanied by the extinction of certain Jurassic types and progressive evolution of the persistent types. Finally, the fossil vertebrates hitherto described from Montana probably are, in part at least, of Mid-Cretaceous or Belly river age.'

The determination of a definite fauna of Belly River age adds greatly to our knowledge of the terrestrial life of Mid-Cretaceous times and helps, very considerably, to bridge over the gap that has hitherto existed between the varied land fauna of the Upper Jurassic and that of the Laramie.

Turtles.	To quote from a recently published review of this memoir 'the fauna described by Mr. Lambe is chiefly of land and fresh-water groups; some marine types, however, are present. There are thirty-four species represented, of which nearly half are new to science. Turtles, especially <i>Trionyx</i> , are very abundant. The Dinosaurs are the largest and most important part of the fauna. The slender, long-limbed and long-tailed, swift running types are represented by a large species of <i>Ornithomimus</i> estimated at twenty-two feet in length. The
Dinosaurs.	most characteristic Dinosaur are of the Iguanodont or duck-billed, and Ceratopsian or horned groups; these show various primitive features when compared with the corresponding forms in the true Laramie. <i>Stereocephalus</i> is a new genus of Stegosaur or plated Dinosaur with very massive skull armour and protective bony rings around the neck, which very much suggest the tail armature of the Edentale <i>Glyptodon</i> .
Mammals.	Two mammals are also described, a rare discovery in any Mesozoic formation.'

Much time has been given to the cleaning, the putting together and setting up many of the specimens preparatory to studying them. The preparation of drawings for the text and plate illustrations has also occupied considerable time. The latter part of the summer was devoted principally to seeing the above report through the press, and since then a catalogue, with a running number, of all the vertebrate remains from the Red Deer River district has been completed.

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The majority of the specimens representing the Belly River fauna, among which are a large number of types, are now ready to be placed on exhibition, but unfortunately there is no space available, at present, for such a purpose, in the museum of the Survey. No museum space for exhibition of new types.

In April Professor Osborn visited Ottawa in connection with the work on the Red Deer river vertebrata, and later in June I was afforded the opportunity of spending a week in New York for the purpose of studying the Cope collections at the American Museum of Natural History.

During October and part of September drawings were made for plates XLII to LI, both inclusive, illustrating part V, volume I. of Mesozoic Fossils.

Collections of fossils, principally corals, have been determined and named for certain officers of the department for use in their reports.

The latter part of the year has been devoted to a critical study of some important and interesting vertebrate remains representative of the Edmonton fauna of the Cretaceous of the North-west.

NATURAL HISTORY OF THE INTERNATIONAL BOUNDARY (49TH PARALLEL).

Mr. James M. Macoun.

During the winter and spring months of 1901-2, such time as could be spared from my work as assistant to Prof. Macoun, was devoted to examining and determining the botanical and other natural history specimens collected near the International boundary in 1901. This work was far from completion when I again went to the field in 1902 and there are still many specimens to be determined. The material collected in 1902 has not yet been touched. Many new species of plants were collected in 1901, descriptions of which have been published in 'The Ottawa Naturalist' and elsewhere. Office work.

When I learned late in April, 1902, that I was to work on the International boundary west of the Columbia river, I at once communicated with Mr. W. Spreadborough who has for so many years acted as my assistant in the field. Mr. Spreadborough being willing to give up the work upon which he was then engaged, I directed him to proceed to Trail, on the Columbia river, a few miles north of the International boundary. He reached there early in May and began Work on International boundary.

at once to collect birds, mammals and plants, making full notes on the migration and nesting habits of the birds.

Join Mr.
S; readbor-
ough.

Being delayed in Ottawa reading proofs of the Catalogue of Birds I did not join Mr. Spreadborough at Trail until June 12. After examining the specimens collected by Mr. Spreadborough, I spent a few days in the vicinity of Trail that I might obtain a thorough knowledge of the plants of that region as they grew. It may be here stated that both Mr. Spreadborough myself had collected in the Columbia valley in 1890, when Prof. Macoun studied the flora and fauna of the Kootenay district. During the time we were at Trail, Mr. W. T. O'Hara, whose party I was later to join, was working between Midway and the Similkameen river. Mr. O'Hara moved so rapidly across this part of the country that it was not thought advisable to have Mr. Spreadborough accompany him as there would be neither time to make large collections nor to properly prepare the specimens. This dry region is one of the most interesting parts of British Columbia from a natural history point of view, and will require to be thoroughly examined before any general report can be written on the country crossed by the International boundary. This examination should be made in May and June as spring and summer come a month earlier than farther to the east and west.

Flora and
fauna of Cas-
cade region.

On June 24, Mr. Spreadborough and I went west to Cascade, where we were joined a week later by Mr. O'Hara's party. We remained at Cascade until July 5, when the whole party started east along the Dewdney Trail. The fauna and flora of the region about Cascade differs widely from that of the Columbia valley as at Cascade the drier country is touched. It is, in fact, the point at which the plants characteristic of the Columbia valley mingle with those of the arid region west of Cascade.

Results.

The remainder of the summer was spent between Cascade and Waneta, at which point the Columbia river crosses the International boundary. The progress of Mr. O'Hara's party being necessarily slow, frequent side trips were made by Mr. Spreadborough and myself for which the requisite transport and supplies were furnished me by Mr. O'Hara. Every high mountain within reach was climbed and though a few species new to science and others new to Canada were collected the results of the summer's work in this respect were somewhat disappointing. This is due in part to the fact that except in the valley of the Kettle river at Cascade, there was no change in the character of the country examined, and, partly because practically the whole region traversed had been surveyed at one time or another by

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members of the Geological Survey staff who had brought home with them botanical and other specimens. It was nevertheless necessary that a thorough examination should be made of the country between the Kettle and Columbia rivers, and from the data collected last season a complete report can now be written. As soon as the snow fell on the higher mountains I returned to Ottawa, leaving Mr. Spreadborough to continue the work east of the Columbia river. He remained with Mr. O'Hara until the end of the season and added many specimens of birds and mammals to those already collected. Following my instructions, he paid special attention to cryptogams, the flowering plants there being out of season. I cannot write in terms of too high praise of Mr. Spreadborough's untiring energy as a collector and it would have been impossible to attain anything like such good results without his assistance.

Mr. Spreadborough's work most satisfactory.

Mr. O'Hara afforded me every needed facility for moving about the country, and my relations with him and with Dr. Daly who accompanied the party as geologist, left nothing to be desired.

THE LIBRARY.

Dr. John Thorburn, Librarian.

During the past fourteen months, from November 1 to December 31, 1902, there have been distributed 13,910 publications of the Geological Survey, comprising reports, parts of reports, special reports and maps. Of these 10,224 were distributed in Canada; the remainder (3,668) were sent to foreign countries as exchanges to universities, scientific and literary institutions and to a number of individuals engaged in scientific pursuits.

The sales of publications during the above period, including reports and maps, numbered 4,735. The amount received since the publication of the last report, was \$641.79.

There were received as donations or exchanges 3,554 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps. Besides these, there were purchased 74 publications. The number of periodicals subscribed for was 40. The number of volumes bound was 260. The number of letters received in connection with the library was 2,252. The letters sent out by the library were 1,897. The number of acknowledgments received was 3,655, and there were sent out 740 acknowledgments from the library.

There are now in the library about 13,200 volumes, besides a large collection of pamphlets. Unfortunately, as has been frequently repeated in previous reports, the space available for library purposes is altogether insufficient, and causes a large amount of unnecessary labour in finding information asked for. It is to be hoped that some provision may be made soon to remedy this.

VISITORS TO THE MUSEUM.

The number of visitors, who signed the museum register during the year was nearly the same as in 1901, namely 37,728.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 56.

There were no changes in the permanent staff during the year.

The funds available for the work, and the expenditure of the department during the fiscal year ending 30th June, 1902, were :—

Details.	Grant.	Expenditure
	£ cts.	£ cts.
Civil-list appropriation	55,200 00	
General appropriations	68,730 00	
Civil-list salaries		48,856 44
Exploration and survey		22,048 36
Wages of temporary employees		23,311 38
Printing and lithographing		16,841 73
Purchase of books and instruments		1,401 51
" chemical apparatus		213 60
" specimens		376 15
Stationery, mapping materials and King's Printer		1,396 87
Incidental and other expenses		2,591 68
Advances to explorers		14,782 99
		131,820 71
Deduct paid in 1900-01 on account of 1901-02		14,234 27
		117,586 44
Unexpended balance Civil-list appropriation		6,343 56
	123,930 00	123,930 00

The correspondence of the Department shows a total of 7,860 letters sent, and 11,239 received.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL,

Acting Deputy Head and Director.

ABBREVIATIONS.

Al.	District of Alberta.	N.W.T.	North-west Territories.
B.C.	Province of British Columbia.	O.	Province of Ontario.
M.	Province of Manitoba.	P.E.I.	Prince Edward Island.
N.B.	Province of New Brunswick.	Q.	Province of Quebec.
N.S.	Province of Nova Scotia.	Y.D.	Yukon Territory.

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